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OBSERVATIONS OF THE NOVEMBER METEORS.

WILLIAM H. PICKERING.

FOR POPULAR ASTRONOMY.

VISUAL OBSERVATIONS.

The meteor shower of November 12–16, 1898, was widely observed throughout the world. This was in part due to the fact that a large number of observers, especially in the more remote longitudes, had courteously offered their services in reply to the request of the Harvard College Observatory. All of these observers made their records according to a uniform plan, and, in consequence, very satisfactory results were obtained. A brief description of these results has already been published in the Harvard Observatory Circular No. 35. A fuller statement will appear later, in the Annals of the Observatory. A much finer shower is expected this year, and it is proposed to continue the observations according to the same plan, such modifications only being introduced as experience has shown to be desirable.

According to a statement by Messrs. Stoney and Downing, published in the *Observatory* for this year, p. 203, the shower is expected to reach its maximum intensity November 15, 1899, at 18^h G. M. T. It is very desirable, however, in order to study the distribution of the meteors in the stream, and also the change in the location of the radiant according to the date, that observers should as far as possible begin work on the evening of November 13, and continue it through the night of November 17. By securing a sufficient number of observers in all longitudes, it is hoped that no hour will pass during the five days in which a watch for meteors has not been kept.

The observations wanted are of two kinds. First, to obtain a continuous record of all the meteors that appear within some definite area of the sky. This can best be secured by a simple count made with the unaided eye, and may be undertaken by any intelligent person without previous scientific training. The second class of observations is intended to locate the radiant, or point from which the meteors seem to come.

In making the count, if the meteors are few in number, count all

those visible in the eastern half of the sky, but keep a special watch on the region represented on the map, POPULAR ASTRONOMY, 1898, Vol. VI, p. 338, that is within 25° of the radiant.* If the meteors come as frequently in this half of the sky as one in two minutes, count only those whose paths lie wholly or in part upon the map. If they come too frequently to make such a list complete, count only such meteors as appear within some selected portion of the map, as for instance within the rectangle formed by the bright stars μ Ursæ Majoris, 40 Lyncis, α and δ Leonis. The stars shown on the map will be found at midnight a short distance above the eastern horizon, and a little to the north of east. In order to make the identification, face the east, hold the map at arm's length, and turn it so that its top shall be towards the pole star. It is recommended that before the count is undertaken, the observer familiarize himself completely with the location of the boundaries of the map as seen in the sky.

The following form of record is recommended to the observer who should fill out the various spaces and columns as described below. The latitude and longitude need only be given approximately, since they are merely needed for identification. The word Time is intended to indicate whether the observer's watch is set according to Standard Time, such as is used throughout the United States and some other countries, or whether it is set to Local Time, which corresponds to the meridian of some place in the immediate vicinity. In the latter case the name of that locality should be inserted. In the former, if in the United States, insert the word Eastern, Central, Mountain, or Pacific according to the time used, in other countries simply use the word Standard. In the column headed Date is to be given the astronomical, as distinguished from the civil day. That is to say, if the observer begin on the evening of Monday, November 13, and continue observing throughout the night, all the observations are to be dated Monday, November 13, whether they occur before or after midnight. In the second column, if half of the sky is observed, indicate the fact by an *S*, if only the region included in the map, indicate it by an *M*, and if only a small portion of the map is used, indicate it with an asterisk. The boundaries of the region in the latter case may be described fully in a note. Under Sky is to be inserted the words, clear, hazy, cloudy, or partly cloudy, according to the condition of that portion of the sky under immediate

* A copy of this map may be obtained by application to Harvard Observatory.

observation. The next three columns give the time of beginning and ending of the observations and the number of meteors observed. If the meteors come very frequently, fifteen minutes or half an hour is as long as it is desirable to work at a time, then after a brief rest one may begin again. If possible, observers should arrange their observations to begin and end either on the even hour or quarter, for convenience in subsequent computation.

In order to avoid frequently looking at a watch, and thus involving the risk of missing some of the meteors, each observer should be provided with a clock and a lantern. Astronomers may find it convenient to record the meteors on a chronograph, from which the table may be filled out later.

Name of Observer.....
Post Office Address.....
Latitude.....Longitude.....Time.....

Frequency of Meteors.						Individual Meteors.					
Date.	R.	Sky.	Began.	Ended.	No.	Date.	Time.	Class.	Magn.	Color.	Remarks.

In general, observations made before midnight are of comparatively little value, as only five to seven per cent. of the meteors are expected to fall before that time in the latitude of Cambridge. On forwarding the records the observer should be careful to mention all the hours when the view was obstructed by clouds, and also the hours when observations were made, but no meteors were seen. Should many meteors be seen to explode, it is recommended that the count be continued only during the alternate quarters of an hour. During the other quarters, when the observer is not resting, he might be occupied in observing and describing meteors of especial interest that may be noted, but it must be remembered that these observations are with one exception of less value than the count.

The second part of the table is intended for a record of these observations. The first two columns give the date and time at which the meteor appeared, the third the class to which it belonged, the fourth its magnitude, the fifth its color, and the

sixth brief remarks regarding it. Longer remarks in the form of notes should be added when desirable. If the meteor came from the direction of the center of the map it was a Leonid and should be marked *l* in the column headed class. If it did not come from that direction it should be marked *n*. Under magnitude should be recorded the brightness of the meteor. A meteor as bright as the faintest star visible should be marked 6. One as bright as the brighter Pleiades 4, if as bright as the pole star 2, if as bright as Arcturus or Capella 0, if as bright or a little brighter than Sirius or Jupiter —2. The brightness of the full moon is about —11. In case the meteor bursts, two magnitudes should be given, one before it bursts and the other at the time of the explosion. The color of the meteor may be indicated by its initial, r, o, y, g, b, w standing respectively for red, orange, yellow, green, blue, and white. In order to secure uniformity of nomenclature, we may define Antares and Aldebaran as red stars, Acturus as yellow, Vega as blue, and Capella as white. In case a meteor bursts, two colors may be given.

Should any meteor be seen to follow a distinctly curved path, a drawing of it may be made upon the chart. If the meteor leaves a luminous trail, the size, shape, and position of the latter should be carefully platted upon the chart with reference to the neighboring stars. This should be done once every minute or two while it remains visible. The exact time of each drawing should be given in the notes. This observation only, should be considered as of paramount importance to the count and three or four of these will be sufficient.

Should the trail fall outside the limits of the map, a rough chart of the stars in its immediate vicinity may be made at the time, these stars to be subsequently identified by the observer by means of any good star map. At the end of the observations the chart and table should be forwarded to the Harvard Observatory, together with any additional notes. Acknowledgement of all observations of value will be made in the final discussion to be printed in the Annals.

Photographic Observations.

On the evening of November 14, 1898, 34 photographs of 11 different meteors, were obtained at this Observatory. The paths of 160 different meteors were also drawn by a number of observers, all young men of intelligence, but the greater part of whom had had no previous training in this class of work. A comparison of the results obtained by the two methods

showed that although the drawings might be useful for other purposes, yet as far as a determination of the location of the radiant was concerned, they had, comparatively speaking, little value. The greatest number of meteors photographed by any single instrument was five. Although a considerable area of the sky was covered by the various instruments employed, perhaps three or four times the area of the circular map, yet in two cases only did the paths photographed extend beyond the region shown upon it. The entire paths of the remaining nine meteors lay within the area covered by the map. The two faintest meteors photographed were estimated visually at the time, as of the second magnitude.

Three types of lens were tested, the wide angle, the rapid rectilinear, and the portrait lens. The first showed the greatest number of bright meteors owing to the larger field of view, and the last the greatest number of faint meteors owing to the larger aperture. The total number shown was about the same. The length of trail as measured on the original negative was greater with the wide angle lens, and since the stellar images can be measured with all needed accuracy, for a determination of a radiant, this type of lens is to be preferred if a mounting driven by clockwork is employed. The other lenses, however, gave satisfactory results, and if a mounting driven by clockwork is not available, a large portrait lens is to be preferred to the other kinds, since it will show a much greater number of star trails, which is a very important matter in locating the meteor's path. The single landscape lens is not to be recommended if any other can be obtained, but still may give useful results should any very bright meteors appear. The telescopic objective has too small a field to be of much use except in a very abundant shower. The full aperture should in all cases be employed, and the larger the plate that can be covered the better. The most sensitive plates obtainable should be used.

During the coming shower it is very desirable that the radiant should be located on the five nights of November 13, 14, 15, 16 and 17. These observations should show the shifting of the radiant with the date, which may be measured quite accurately by this means, and further, photographs taken at different hours at the same station, should show the influence of the mass of the Earth and its rotation upon the radiant, quantities which it is probable are quite large enough to be measured photographically. It is therefore recommended to all astronomers that an endeavor be made to obtain photographic results during the coming shower.

The meteors may be photographed either with or without clockwork, the stars appearing either as dots or lines. There are three reasons, why a camera may be advantageously attached to an equatorial mounting and driven by clockwork. First, many more stars will be photographed than if they are allowed to trail. Secondly, if the image of the star in the finder is occasionally examined, and the telescope adjusted so that round stellar images may be obtained, greater accuracy in right ascension will be secured. Thirdly, if the meteor photographed is not observed visually, that fact is of little consequence as far as a determination of the location of the radiant is concerned, if the instrument is provided with clockwork.

Since the radiant is constantly, although slowly changing, it is desirable even with clockwork to know the approximate time at which a meteor appeared. It is therefore recommended that the plate be changed at least as often as once an hour. Since the Moon is nearly full, it is possible that still shorter exposures will be necessary, in order to avoid fogging the plate, in case a portrait lens is employed. Another but less satisfactory remedy would be to stop down the lens. It is well to carry on visual observations at the same time including drawing the path of all meteors of the second magnitude or brighter, appearing in the region covered by the map.

The camera should be attached to the outer end of the telescope tube instead of to its middle, as might at first seem more convenient, as otherwise the edges of the slit in the dome are liable to interfere with the view. If the slit is wide enough, or an outdoor equatorial stand is available, several cameras may be attached to it, pointing to different portions of the heavens.

In every case, however, the radiant should fall upon the plate. With two cameras it is recommended that the radiant should fall near the middle of the northern edge of one plate and near the middle of the southern edge of the other. With three cameras, two should photograph the region preceding the radiant, and one that following it, since early in the evening more meteors, which are nearer and therefore brighter, precede the radiant than follow it.

Since the ordinary bellows camera is only intended to be used in a horizontal position, its joints should be thoroughly braced before it is attached to the telescope, otherwise we shall find that the distance from the lens to the plate will vary with the altitude throwing the images out of focus. In order to test the matter thoroughly, photographs should be taken at various al-

titudes with slight changes of focus several nights before the shower. A few long exposures should then be given at different altitudes, on some point having the same declination as the radiant, in order to determine if the axis of the photographic lens remains at a fixed angle with that of the telescopic finder. This is a matter of the highest importance, and is very liable to give trouble unless the camera is firmly lashed to the telescope, and the finder is fitted securely. The plates should all be numbered in the corner, on the film side, with a soft lead pencil, or, better still, in copying ink.

If only a few meteors are photographed, as will be the case upon the nights immediately preceding and following the shower, it will be very difficult for any single observer to secure a satisfactory determination of the location of the radiant. By combining his results, however, with those obtained at other observatories much more satisfactory results may be obtained. For this reason it is desired that all original negatives showing meteors taken during the present shower may be forwarded to this Observatory at its expense. They will then be examined, measured, and returned to the senders, if desired. If it is not practicable to forward the original negative, a glass contact print from it would be the next most desirable record, or a print upon a flexible film, which may be sent by mail.

A single bright meteor if photographed from two or more stations suitably located would furnish all the material necessary for a determination of the radiant. These stations might be, in general, from ten to forty miles apart. For photographic observations of parallax the lesser distance would probably prove the more satisfactory, and one station should be nearly north of the other.

We will now discuss the best method of photographing the meteors when an equatorial mounting driven by clockwork is not available for the support of the camera. It is thought that if the following suggestions are carefully carried out, that the results obtained will be but slightly less accurate than those secured by means of clockwork. They will certainly be far more reliable than those secured by the most skillful astronomer who trusts solely to visual observations.

The best lens to use for this work is undoubtedly a large, old-fashioned portrait lens, but it may well be supplemented by a wide angle lens, the radiant being central in the field of each. A very convenient and simple form of camera consists merely of two rectangular wooden tubes, one sliding inside of the other.

These should be blackened upon the inside. The lens is attached to the outer tube, and a suitable frame to hold the plate holder fastened to the inner one. If these tubes are well fitted, once they are properly focused, four screws may be driven into them, holding them firmly together, and they will remain immovable regardless of the angle they make with the horizon. A simple form of equatorial mounting consists in attaching the camera so as to point upward from a base, at a fixed angle of 22°, equal to the declination of the radiant. The base is pivotted to turn upon a board placed parallel to the equator. A series of holes, in any one of which a peg may be inserted, serves to adjust the camera in right ascension to any desired hour angle. By this device considerable time is saved in shifting and pointing the camera or cameras. Harvard Observatory Annals, Vol. XLI, p. 147. If a bellows camera is used alone, without any accessary mounting, it had best be firmly attached to a board which can be inclined against a box at a suitable angle.

The quickest method of focusing the camera is as follows: Focus by daylight on some distant object, mark the focus on the camera, push the lens in about two millimeters and point on some bright star at night, by sighting along the edge of the camera. Expose the lens for thirty seconds, and then without moving the camera lengthen the focus one millimeter. Expose again and so on for five exposures. Let the last exposure have one minute duration to distinguish it from the others. On developing the plate it is probable that nothing will be seen until it is finally fixed, and can be examined in a good light. Then five short lines will appear, due to the motion of the star in the heavens. The best focus can be interpolated from among them. It is well to point in some region of the heavens containing several bright stars such as the constellation of Orion, for since the focus varies in different portions of the plate a better selection can thus be made.

Each time before exposing the camera, on the night of the shower, it should be set by sighting along its edge so as to point at ε Leonis. Owing to the motion of the stars this will bring the radiant near the center of the plate at the middle of the exposure.

On account of the length of the star trails, it is better that the exposures should not exceed one half hour in duration. The exposures should be closed exactly on the hour and half hour, which allowing for the time required to change the plates, will make the exposures a little short of thirty minutes. A brief ex-

posure of two seconds should be given just before and after the long exposure. The time of these exposures should be taken with the greatest care in hours, minutes and seconds, and also the time that any bright meteor crosses the field of view of the lens, as the difference between these times gives the right ascension of the radiant. The course of the meteor should then be drawn as carefully as possible upon the circular map, and finally a description of it given as previously described.

The chief error affecting this method of observation consists in noting the time that the meteor crosses the field of view. This error may, it is found, readily amount to many seconds. By the use of a chronograph or a stop watch the difficulty is largely avoided. In default of those instruments the error may be greatly reduced if an assistant will keep his eye steadily fixed upon his watch, while the observer fixes his on the sky. The instant a bright meteor is seen crossing the field of view of the lens the observer calls "tip," and the assistant records the time. Being relieved of the necessity of looking at the watch, the observer can moreover make his other records with much greater accuracy.

If but few meteors are seen, it will not be necessary to change the plate at each exposure. In the case of the wooden equatorial mounting, any slight inaccuracies in fixing the board parallel to the plane of the Earth's equator will cause successive trails of the same star to deviate from one another. If the various exposures differ among themselves by ten or twenty seconds, the corresponding differences in the lengths of the star trails will be quite marked. There will therefore be no difficulty in determining which set of star trails correspond to the trail of the meteor. It is recommended, however, that not more than three or four meteor trails be allowed to fall upon any one plate.

HARVARD COLLEGE OBSERVATORY,
September 16, 1899.

EPHEMERIDES OF TWO SITUATIONS IN THE LEONID STREAM.

G. JOHNSTONE STONEY AND A. M. W. DOWNING.

The *ortho-Leonids*, the dense part of the great procession, will probably be streaming across the Earth's orbit next November. The Earth will reach the node probably not far from the epoch

1899, November $15^d\,18^h$ (see *Proceedings of the Royal Society*, vol. 64, p. 409). At that time, were it not for moonlight, an endlong photograph of the part of the stream which is near the Earth but outside the atmosphere might perhaps be secured by pointing the telescope along the tangent of the meteoric orbit, which would require it to be pointed towards a situation in the heavens some degrees distant from the radiant point. But as the Moon will be nearly full, it seems hopeless to obtain this photograph.

Under these circumstances, and as Dr. Isaac Roberts expressed his willingness to make another attempt to photograph the *Leonids* while outside the Earth's atmosphere, the best course appeared to be to provide an ephemeris which will enable observations to be made on groups of nights upon which the Moon will not interfere, and which come near the date on which the Earth reaches the node. This is done in the subjoined ephemerides. The Earth is so situated on those dates that an actually tangential view of the stream cannot be obtained, and accordingly we had to be content with computing the ephemeris for situations in the stream where it makes a small angle with the line of sight. Two such situations were selected, one to be observed in the group of nights free from moonlight which come next before November 15, and the other to be observed in the group of dark nights following that date. The first of the selected stations is the perihelion of the osculating ellipse of the part of the stream which the Earth encountered in 1866, and the other is the point along the same ellipse of which the mean anomaly is 30°. The osculating ellipse was obtained by allowing for the perturbations since 1866, as calculated in a paper on the perturbations of the *Leonids* read before the Royal Society last March, and published in the *R. S. Proceedings*, vol. 64, p. 403.

The ephemerides have been computed both for the above mentioned points and for points along the ellipse close to them, in order that it may be possible for the observer to foresee the position in his field of view of the tangent to the meteoric orbit. It may be expected that the meteors, if they can be photographed at all, will present themselves as a dim streak, like the faint part of a comet's tail, crossing the photographic plate in the direction so determined.

An inspection of the ephemerides shows that the direction in which the stream will cross the field of view in the observation to be made on the earlier group of nights is from the *nf* quadrant towards the *sp* quadrant, the position angle being about

50° on October 31, 40° on November 6, and 6° on November 12. In the observations to be made at the end of November and beginning of December, the apparent direction of the stream in the field of view will again be from the *nf* quadrant towards the *sp* quadrant, but the position angle will change but little during this fortnight. It will be between 53° and 55°.

Ephemeris I. records the apparent positions of the perihelion of the above mentioned osculating ellipse from midnight on 1899 October 31 till midnight on November 12.

Ephemeris II. records the apparent positions on the same dates of a point on the ellipse of which the mean anomaly is 0° 1′.

Ephemeris III. records the apparent positions as seen from the Earth at midnight from November 29 till December 11 of that point of the ellipse of which the mean anomaly is 30°.

Ephemeris IV. records the apparent positions on the same dates of a point on the ellipse of which the mean anomaly is 31°.

The computations have been made by Mr. Thomas Wright, of the staff of the *Nautical Almanac* Office, and the expense of the computation has been defrayed out of the Donation Fund of the Royal Society.

Greenwich Midnight 1899	Right Ascension. I.			II.			Declination. I.		II.	
	h	m	s	h	m	s	°	′	°	′
Oct. 31	9	41	23	9	43	7	N 18	5	N 18	26
Nov. 1	9	44	10	9	45	54	18	4	18	27
2	9	47	2	9	48	45	18	5	18	28
3	9	50	0	9	51	41	18	6	18	30
4	9	53	5	9	54	43	18	9	18	34
5	9	56	20	9	57	55	18	13	18	39
6	9	59	45	10	1	17	18	19	18	46
7	10	3	23	10	4	51	18	27	18	56
8	10	7	18	10	8	40	18	38	19	9
9	10	11	36	10	12	49	18	52	19	25
10	10	16	23	10	17	23	19	12	19	46
11	10	21	47	10	22	29	19	37	20	12
12	10	27	56	10	28	13	N 20	7	N 20	45
	III.			IV.			III.		IV.	
29	14	15	48	14	17	15	S 7	12	S 7	27
30	14	16	8	14	17	35	7	13	7	29
Dec. 1	14	16	28	14	17	54	7	14	7	30
2	14	16	48	14	18	13	7	16	7	31
3	14	17	7	14	18	32	7	17	7	32
4	14	17	26	14	18	51	7	18	7	34
5	14	17	44	14	19	10	7	19	7	35
6	14	18	3	14	19	28	7	21	7	36
7	14	18	21	14	19	46	7	22	7	37
8	14	18	39	14	20	4	7	23	7	38
9	14	18	57	14	20	22	7	24	7	39
10	14	19	15	14	20	40	7	25	7	40
11	14	19	33	14	20	58	S 7	25	S 7	41

THE PERSEIDS OF 1899.

JOHN A. MILLER.

FOR POPULAR ASTRONOMY.

Mr. W. S. Pinkerton, principal of the Huntington (Ind.) high school, and the writer watched the Perseid meteors for a period of time varying from one to four hours on every clear night from August 2 to Aug. 19, Mr. Pinkerton doing all the watching after Aug. 12. Unfortunately, however the clouds were so troublesome from the ninth to the thirteenth that our observations for horary numbers, during those nights are of no value. A sufficient number of paths of meteors were plotted however, to obtain radiants even for those nights. The observations of Mr. Pinkerton did not show a *regular* progression of the radiants. They did show however that there are at least two radiants in Perseus. I have called them P_I and P_{II}. The paths of P_I intersect within a circular area of radius about 2¼°, and center at R. A. 42° Decl. 57°.6. The paths of P_{II} intersect within a circular area of about the same size, and with its center at R. A. 45° Decl. 48°.

Mr. Pinkerton's observations also showed a shower of Triangulids. The maximum of this shower occurred at about 2:45 o'clock Aug. 4. I did not observe any Triangulids from twelve o'clock to two, on the same morning, while Mr. Pinkerton recorded 7 from two o'clock till four, three of which fell from 2:45 till 3:00. The seven paths that he plotted intersected almost exactly in a point. The radiant thus determined is R. A. 37°.5 Decl. 34°.6.

During my observations, I noted only those meteors which I supposed were Perseids. The paths plotted show the following radiants:

Aug. 4	P_I	R. A. = 42°	Decl. = 57° 6
	P_{II}	R. A = 45°	Decl. = 48°
Aug. 8	P_{II}	R. A. = 46°	Decl. = 48°
Aug. 11	P_I	R. A. = 47°	Decl. = 56° 7

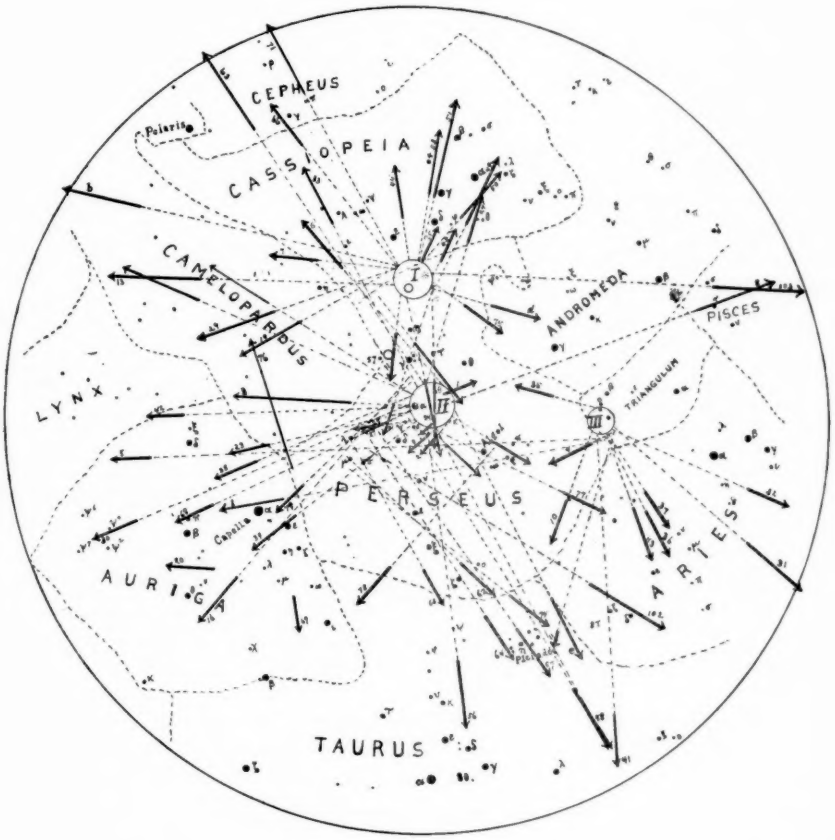
It will be noted that P_I shaws a progression from west to east while P_{II} coincides exactly with P_{II} determined by Mr. Pinkerton.

The meteors from radiant P_{II} were usually swift, faint, rarely brighter than a star of the third magnitude, and in case they left a trail, which they rarely did, it was also very faint. The meteors of the radiant P_I usually moved more slowly, were bright-

er, and many of them left fine trails, particularly those that fell during the evenings of Aug. 9th and 11th.

The periods of activity of the two radiants were about equal; from both radiants meteors came as early as Aug. 2, and as late as Aug. 19. The number coming from radiant P_{II} somewhat exceeded that coming from P_{I}.

Mr. Pinkerton's observations showed also that there probably is a radiant near λ Persei, though, it is barely possible that errors in plotting the paths may have made it appear so.



THE PERSEIDS OF 1899.

On the accompanying map are found trails recorded by Mr. Pinkerton, and two very small circles which mark the position I obtained for the radiant P_1 on the evenings of Aug. 4 and Aug. 11 respectively—the one near 57 Cephei being that found on the latter date.

The accompanying table will show the horary numbers, state of the weather, etc. Under the head observer, P refers to Mr. Pinkerton, M to the writer, and S to Mr. Slipher who was at Frankfort, Ind., on the night of the 11th where it was clear. Under the heading class P_1 refers to those coming from the first radiant, P_{II} those from the second, T to the Triangulids and N any other meteor that happened to be observed, though all that were observed were in the neighborhood of Perseus.

Date.		Horary Number.	Class.				Observer.	State of Sky.
			P_1	P_2	T	N		
Aug. 2	12 M –2 A. M.	6	2	2		2	M	Clear and Moonless.
" "	2:30-3:30	11	3	5		3	P	" " "
Aug. 3	2:30-3:30	10	2	4		4	P	Sky clear.
Aug. 4	12 M.-2 A. M.	7	3	1		3	M	Clear and Moonless.
" 4	2:00-3:00	8	—	2	5	1	P	Clear except slight haze.
" 4	3:00-4:00	5	—	3	1	1	P	" " " "
Aug. 5–7								Cloudy.
Aug. 8	12:45-1:45	11	1	4		6	M	Cloudy over Perseus 12:40–1:00.
Aug. 9	11:00-12:00	6	1	2		3	M	Cloudy over part of the sky.
Aug. 11	8:30-9:05	54	—	—	—	—	S	Clear.
Aug. 16	1:00–2:00	16	3	2		scattered	P	Clear.
" 17	1:03-2:03	11	3	3			P	
" 18	1:54–2:54	13	2	3			P	Sky clear, Moon shining.
" 19	3:05–3:50	10	2	2		6	P	

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BRIEF REVIEW OF SOLAR OBSERVATIONS, JANUARY TO AUGUST, 1899.

DAVID E. HADDEN.

FOR POPULAR ASTRONOMY.

The following summary of solar observations made during the above eight months of the current year are intended to be but a brief rèsumè of the daily observations with notes on the larger or more interesting groups or spots.

While we are rapidly approaching the period of solar activity when the spots are smaller, fewer and more transitory, still several very interesting spots, and in June one quite large one was observed.

The following table exhibits the numerical results of the daily observations, a 4-inch telescope being used :—

1899. Months.	Number of days of observation.	Average daily No. of Groups.	Average daily No. of Spots.	Average daily No. of Faculæ.	No. of days without Spots.	Average daily No. of groups in Northern Hemisphere.	Average daily No. of groups in Southern Hemisphere.
January.....	22	1.95	10.0	1.9	1	0.2	1.7
February.....	18	1.11	4.8	1.8	9	0.0	1.1
March.....	17	1.48	5.5	1.4	3	0.3	1.2
April.....	22	1.73	3.2	1.5	1	0.3	1.5
May	23	0.71	2.6	1.0	8	0.0	0.7
June.....	25	1.60	10.0	1.6	2	0.7	0.9
July	29	1.52	6.7	2.0	8	0.4	1.1
August.....	27	0.33	0.6	1.7	23	0.2	0.1

JANUARY.

There was a slight increase in the average number of spot groups visible on the disc this month, the average number being 1.95 perday, as compared with 1.44 in December, while the number of spots was doubled. Only three groups completed the entire transit of the disc. A small group first seen on December 31st at the east limb, which was closely followed by another group on January 2d formed a rather broken train until they passed the central meridian, after which the individual spots diminished and but few dots were left when disappearing at west limb. On the 5th a fairly large group appeared at the east limb, and a brilliant point of light, probably overlying facula, was noticed in the umbra of its larger preceding spot, which was not visible next day, during this group's transit, many interesting changes took place, and a peculiar cyclonic motion of the umbra of the preceding spot was observed, changing from an east and west direction on the 7th to a north and south on the 14th, it disappeared at the west limb on the 20th reduced to a few small spots. No spots were on the disc on the 21st.

FEBRUARY.

But few groups were on the disc this month, all of which consisted of quite small and uninteresting spots. The disc was free from spots from the 11th to 18th inclusive, also on the 26th.

MARCH.

There was a slight increase in the average daily number of groups and spots visible this month. During the first few days, a group which consisted of but a few dots during the closing days increased greatly in size and passed over the west limb with evidences of much activity.

On the 15th a group of small spots in prominent faculæ was at the east limb and was the only group which completed the entire transit of the disc during the month, it rapidly increased in size and on the 18th had two large umbræ, which were increased to three on the 19th, and coalesced into one large irregular one on the 22d, pear-shaped on the 23d, breaking up next day and disappearing beyond the west limb on the 26th. Another group which proved of interest appeared at the east limb on the 26th, its umbra was noted as appearing unusually dark in an oval penumbra. Next day the major axis of the oval penumbra was in a north and south line, on the 28th the penumbra was more circular with dark double cone shaped umbra, extending in a southeast and northwest direction, and on the 30th it was a fine typical oval spot with elliptical umbra elongated east and west.

APRIL.

The month opened with the single large spot near the central meridian, still oval, but its umbra appears slightly broken. On the 3d the penumbra was more circular and the umbra more inclined towards a northeast and southwest direction and containing a faint bridge which on the 4th had divided the umbra, the spot disappeared on the 7th, the group reappeared on the 22d. No penumbra was apparent on the west edge of its umbra on the 23d, but from the 24th to the close of the month, it remained visible as a typical circular normal spot. Only one spotless day was noticed in April, viz. the 8th.

MAY.

The solar surface was observed on 23 days during May, and at no time was more than one group visible, the disc was unspotted on seven days. During the first few days of the month, the normal spot noted in April was advancing towards the west limb, beyond which it disappeared during the forenoon of the 5th. It reappeared for the third time on the 19th at the east limb, and from the 22d to 26th appeared normal with several small spots appearing and disappearing in its vicinity. It was reduced to a small spot with hardly any perceptible penumbra on the 29th and 30th but as it neared the west limb on the 31st, four or five small spots suddenly broke out in its vicinity and evidently another period of activity commenced on the invisible side of the Sun.

JUNE.

During the first two weeks of the month, only small scattered groups of small spots were visible. On the 12th a small train of

spots was near the east limb, which increased for a few days, but faded out on the 19th. On the 23d the largest and most prominent group of the year appeared by rotation at the east limb, it was an oval shaped penumbra directed in a north and south axis, containing an irregular umbra which is perhaps divided, but the spot is yet much foreshortened. On the next day the umbra was slightly "bridged," in oval penumbra with its axis more inclined in a westerly direction. On the 26th the penumbra appeared to be more circular with a more compact but irregular umbra, and numerous small spots closely preceding and following the spot which is quite large. With the spectroscope much disturbance was noted in the vicinity, the H_α line being reversed in numerous places, but owing to clouds, further observations could not be obtained. On the 27th the spot was larger and more oval, the umbra also roughly oval with its axis in an east and west direction, the umbra was a deep purple tint, and near its center was an intensely black hole or nucleus, no prominent disturbances could be detected in the group with the spectroscope.

On the 28th the umbra was longer, but the following portion of it was branched into 3 parts, while a small preceding portion was "bridged" and about to become detached, the entire umbra was lighter shade of gray and purple in which the small black nucleus was conspicuous. On the 29th the umbra was narrower and pointed at the following end, while the preceding portion is detached in one or two places, the dark nucleus is still present but not as prominent, no disturbances noted with the spectroscope. On the 30th the umbra was more irregular with appearance of breaking up, a brilliant white circular "bridge" nearly encircles the small detached part of the preceding portion of the umbra, the spot was accompanied by a multitude of very small spots during the above period.

JULY.

The large spot of the last week of June was fast breaking up and diminishing during the first few days of the month and disappeared by solar rotation during the late afternoon of July 4th. On the same day, another spot of medium-large size appeared at the east limb which completed the transit of the disc, disappearing by rotation about noon on the 16th. It was interesting mainly on account of its constantly changing umbra which was oval, elongated, triangular and irregular. No spots were visible from the 17th to the 24th and during the remaining seven days of the month, only a few very minute spots were seen.

AUGUST.

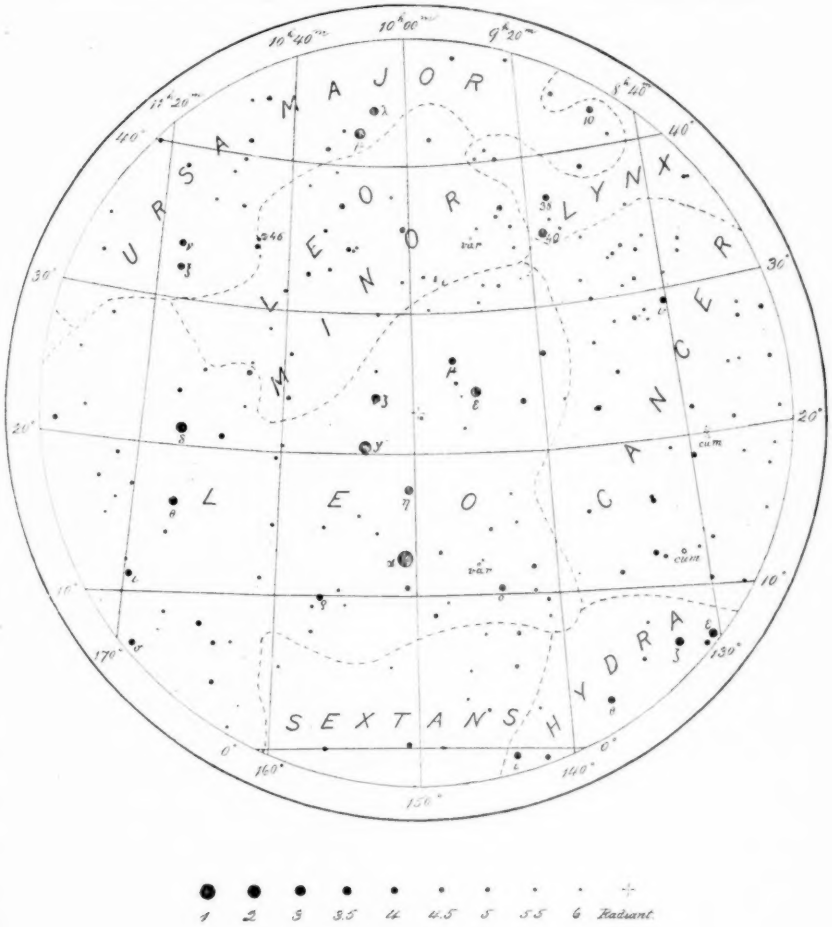
With the exception of a few days in the beginning, and a few towards the latter part of the month, when only very minute dots were seen, the present month was nearly spotless. No spots were observed on 23 days. This is the most prolonged period of unspottedness since the latter half of the year 1890, when my sun-spot observations were begun, and is indicative of the apparently rapid approaching minimum period.

ALTA, IOWA,
Sept. 7th, 1899.

THE NOVEMBER METEORS OF 1899.

EDWARD C. PICKERING.

The predicted time of maximum of the November meteors is November 15, 1899, at 18^h Greenwich Mean Time. As a similar shower may not occur again for thirty years, no pains should be spared to secure the best possible observations. The most useful observations that can be made by amateurs are those which will serve to determine the number of meteors visible per hour throughout the entire duration of the shower. Circular No. 31 was accordingly distributed last year, and numerous valuable observations were thus secured from observers in all parts of the world. The results, some of which are given below, are now being discussed by Professor W. H. Pickering, and will be published later in the Annals. Similar observations are desired this year, and it is hoped that they may be made on November 15, and also on the two preceding and following evenings. The most important time for observation is from midnight until dawn, as comparatively few meteors are expected earlier. Observations are particularly needed at hours when they cannot be made at the Observatories of Europe and America. In general, the time required for ten or more meteors to appear in the region covered by the accompanying map, should be recorded. This observation should be repeated every hour or half hour. If the meteors are too numerous to count all those appearing upon the map, the observer should confine his attention exclusively to some small region such as that included between the stars μ Ursae Majoris, 40 Lyncis, δ and α Leonis. If the meteors occur but seldom, one every five minutes, for instance, the time and class of each meteor should be



recorded. Also, note the time during which the sky was watched and no meteors seen, and the time during which that portion of the sky was obscured by clouds. Passing clouds or haze, during the time of observation should also be recorded. The date should be the astronomical day, beginning at noon, that is, the date of early morning observations should be that of the preceding evening. Specify what time is used, as Greenwich, Standard, or Local Time. When a meteor bursts, make a second

observation of its light and color, and when it leaves a trail, record the motion of the latter by charting the neighboring stars, and sketching its position among them at short intervals until it disappears, noting the time of each observation. If the path of a meteor is surely curved, record it carefully upon the map.

On November 14, 1898, thirty-four photographs were obtained of eleven different meteors. Their discussion has led to results of unexpected value. The greatest number of meteors photographed by one instrument was five. Only two meteors were photographed which passed outside of the region covered by the map, although the total region covered was three or four times as great. No meteors fainter than the second magnitude were photographed.

Photographs may be taken, first, by leaving the camera at rest, when the images of the stars will trail over the plate and appear as lines, or secondly, attaching the camera to an equatorial telescope moved by clockwork, when a chart of the sky will be formed, in which the stars will appear as points. A rapid-rectilinear lens is to be preferred in the first case, a wide-angle lens in the second. The full aperture should be used, and as large a plate as can be covered. The most rapid plates are best for this work; they should be changed once an hour, and the exact times of starting and stopping recorded. Care should be taken to stiffen the camera by braces, so that the focus will not be changed when the instrument is pointed to different portions of the sky, especially if the lens is heavy. If the first method is employed, the position of the camera should be changed after each plate, so as to include as much as possible of the region of the map on each photograph. If pointed a little southeast of ε Leonis, the radiant will reach the centre of the field about the middle of the exposure. A watch of the region should also be kept, and the exact time of appearance and path of each meteor as bright as the Pole Star should be recorded. The plates should be numbered on the film side with a pencil, and should be sent to this Observatory with accompanying notes and other observations. After measurement here, they will be returned if desired. The value of the results will be much increased if similar photographs can be obtained by a second camera from ten to forty miles distant, and preferably north or south of the other.

HARVARD COLLEGE OBSERVATORY.

Circular No. 45.

September 18, 1899.

THE APPROACHING STAR SHOWER.

LEWIS SWIFT.

FOR POPULAR ASTRONOMY.

As is well known the periodical return of the great star shower of November 12, 1799, November 13, 1833, and November 14, 1866, is near at hand and as but few probably of your readers saw that of 1833, which far surpassed the others, if not all that history records in the brightness and number of the meteors seen, it seems that a description of it as seen by me, may not be wholly without interest, though possessing no scientific value. I was a boy not yet fourteen years of age, but the memory of that awful night clings tenaciously to me yet.

The simple circumstance of the stopping of our clock, which I never knew it to do before, was the cause of my witnessing it. My father was an early riser, and not knowing the time he ventured to call an elder brother up to make a fire and get a pail of water from a dangerous open well. As he opened the door, he uttered a scream which father thought indicated that he had fallen in the well, and rushing out to rescue him, he was not long in deciding what caused the scream. The entire family were called up to see the stars fall. I am not going to even attempt to describe the wondrous scene, for the most gifted pen would fall far short in describing it. They fell like flakes of fiery snow in a moderate snow storm. It was estimated that at least 200,000 were seen from any one point, and this all the way from Greenland to Patagonia. I noticed that they appeared all over the sky, bright and faint, with short and long train, but was too young to observe it scientifically, and failed to notice that the trails if traced backward would meet at a certain place like the spokes of a wheel.

Not one was seen to reach the earth though many were very bright. The sky was perfectly clear, and the moon absent. It was a rain storm without a cloud, lightning without thunder. What made the deepest impression on my youthful mind was the deathlike silence above and around me. Seeing such a display of energy going on and hearing no noise, the silence was as depressing and solemn as in a room of the dead.

People ran to their neighbors crying the world is coming to an end, the stars are falling. Many amusing incidents are recorded as having occurred during the shower. A distant neighbor lived opposite a blachsmith shop, in which at that time charcoal only

was used which makes many sparks. Awaking and looking out of the window said to himself, "the blacksmith has got to work pretty early this morning" and again went to sleep.

The shower was not visible in this country in 1866, but was on the eastern continent. On November 15, 1867, while the earth was passing through one end of the dense swarm, having the previous year passed through its center, I expected something of a display, and was not disappointed for I counted nearly 1100, the greatest number seen in the southeast and northwest with many very short trails. The line must be sharply drawn between shooting stars and bolides, from some of which heavy masses fall to the earth called meteorites, or meteoric stones. On the other hand no shooting star has ever been known to reach the earth, the encounter with, and friction of the atmosphere, instantly reduce them to vapor.

Many meteoric showers are known. Prof. Denning, of England, our best authority on meteoric astronomy, enumerates some 200 or more. This Leonid shower, as it is called, will repeat itself again, commencing a little after midnight of November 15, lasting till dawn, and not on the 14th as some have published. There is a bare possibility that it may be on the morning of the 16th. It would be well, however, to begin the watch on the 14th.

LOWE OBSERVATORY, Echo Mountain, Cal.

September 8, 1899.

HOW TO FIND THE DAY OF THE WEEK ON WHICH ANY DAY OF ANY YEAR FALLS AND ALSO HOW TO DETERMINE THE EASTER DAY FOR MANY YEARS.

ALEXANDER RYDZEWSKI.

FOR POPULAR ASTRONOMY.

I have not happened to meet in any book treating of chronological astronomy so simple rules for the determination of the Easter Day for any year and also of the week's day on which falls everyday of this year, that all the calculations could he made mentally without tables. Therefore I suppose the following simple rules will be interesting to the readers of POPULAR ASTRONOMY.

I have no intention to expound here how the formulas are derived because, I suppose, anyone can easily, after thoroughly inspecting these formulas, derive them himself.

The following numbers are affixed to the days of the week: to

Sunday, 0; to Monday, 1; to Tuesday, 2; to Wednesday, 3; to Thursday, 4; to Friday, 5; and to Saturday, 6. These numbers can be called *characteristical numbers of the day of the week.*

The numbers affixed to the months of 0 year of our era are following: to January, 4; to February, 0; to March, 0; to April, 3; to May, 5; to June, 1; to July, 3; to August, 6; to September, 2; to October, 4; to November, 0; and to December, 2. Call them *characteristical numbers of the months.*

The set of these last numbers written in groups of three numbers is following:

$$4, 0, 0;\quad 3, 5, 1;\quad 3, 6, 2;\quad 4, 0, 2.$$

This set can be easily memorized after attentive inspection, if we observe: (1) that all the numbers are less than 7; (2) that the first and the fourth groups are composed of even numbers and the second of odd; (3) that the first number of the first and of the fourth groups as well as of the second and of the third are the same: 4 and 3 respectively; (4) that the second and the third numbers of the third group exceed the same numbers of the second group by 1, and so on.

Denote: (1) by $Q_p A$ and $R_p A$ respectively the quotient and the remainder of any number A divided by p and (2) by $N = 100\,m + n$ the number of the given year of Christian era. Then the characteristical number A of the year N will be, for the Julian calendar:

$$a = R_7\,(n + Q_4 n - m); \tag{1}$$

the characteristical number a', for the Gregorian calendar, will be:

$$a' = R_7\,(a + \Delta), \tag{2}$$

where

$$\Delta = 2 - R_7\,(m - Q_4 m). \tag{3}$$

when a or Δ are negative 7 must be added to them. We can easily obtain for a given date, say D, of any month of any given year the day of the week with a and a' calculated for this year by formulas (1), (2) and (3). This day is derived from formulas

$$(4)\quad \begin{cases} W = R_7\,(a + M + D) \text{ for the Julian calendar,} \\ \quad = R_7\,(a' + M + D) \text{ for the Gregorian calendar,} \end{cases}$$

where W and M are respectively the characteristical numbers of the week's day and of the given month. In all of these instances M must be diminished by 1 for January and February of the leap years. a is calculated for the years $N = 100\,m + n$ before Christian era by the following formula:

(5) $$a = R_7 \{7 - R_7 [n + Q_4 (n-1) - m]\}$$

a must be augmented by 1 for all the months of the leap years (B. C.) except January and February. Leap years B. C. are those giving after dividing them by 4 the remainder 1.

EXAMPLES.

(1) What day of the week was the birthday of Newton, 25 December, 1642, (Old Style)?

$$a = R_7 (42 + Q_{42} - 16) = R_7 (36) = 1;$$
$$W = R_7 (1 + 2 + 25) = R_7 (28) = 0 = \text{Sunday}.$$

(2) What day of the week was the birth's day of Charles Darwin, 12 February, 1804 (New Style)?

$$a = R_7 (4 + Q_4 4 - 18) = R_7 (-13) = -6 \text{ or } 1;$$
$$\Delta = 2 - R_7 (18 - Q_4 18) = 2 - R_7 (14) = 2;$$
$$a' = R_7 (1 + 2) = 3;$$
$$W = R_7 (3 + 0 + 12) - 1 = R_7 (15) - 1 = 1 - 1 = 0 = \text{Sunday.}^*)$$

One can easily determine Easter Day for any given year, $N = 100\,m + n$, knowing a and a' for this year, by the following formulas:

I. FOR THE JULIAN CALENDAR.

(6) $$b = R_{19} (5\,m + n + 4);$$

(7) $$c = 30 - R_{30} (11b);$$

when $b = 0, 1, 2$ or 3, c must be augmented by 1; but, as c can't be > 30, for $b = 0$, c is not $30 + 1$ but $31 - 30 = 1$.

(8) $$d = R_7 \lfloor 7 - R_7 (a + c) \rfloor;$$

(9) Easter Day $= (21 + c + a)$ March, or, if $c + d > 10$
$= (c + d - 10)$ April.

II. FOR THE GREGORIAN CALENDAR.

b is the same as obtained by formula (6)

(10) $c' = c + \Delta_1$, or $c + \Delta_1 - 30$, when $c + \Delta_1 > 30$

(11) $$d' = R_7 \lfloor 7 - R_7 (a' + c') \rfloor;$$

where c is the same as for the Julian calendar (Form. 7) and

(12) $$\Delta_1 = R_{30} (m - Q_3\,m - Q_4 m);$$

(13) Easter Day $= (21 + c' + d')$ March, or if $c' + d' > 10$
$= (c' + d' - 10)$ April.

* W is diminished by 1 because 1804 is a leap year.

There are two exceptions to formula (13) the same as in the formula for calculation of the Easter Day given by Gauss:

(1) when $d' = b$ and $c' = 30$, and

(2) when $d' = b$ and $c' = 29$ and simultaneously $b - 4 > 10$*

In these two cases the Easter Day will be a week soon as calculated by formula (13).

For the Julian calendar the formula (9) is always true.

EXAMPLES.

(1) Determine the Easter Day (for both calendars) in the year 1899.

$$a = R_7 (99 + Q_4\, 99 - 18) = R_7 (105) = 0;$$
$$b = R_{19} (90 + 99 + 4) = R_{19} (193) = R_{19} (98) = 3;$$
$$c = 20 - R_{30} (33) + 1 = 31 - 3 = 28;$$
$$d = R_7 [7 - R_7\, 28] = R_7 (7) = 0;$$

Easter Day (Old Style) = (28 + 0 − 10) April = 18 April.

$$\Delta = 2 - R_7 (18 - Q_4\, 18) = 2;$$
$$a' = R_7 (a + \Delta) = R_7 (2) = 2;$$
$$\Delta_1 = R_{30} (18 - Q_3\, 18 - Q_4\, 18) = R_{30} (18 - 6 - 4) = R_{30} (8) = 8;$$
$$c' = c + \Delta_1 - 30 = 28 + 8 - 30 = 6;$$
$$d' = R_7 \lfloor 7 - R_7 (2 + 6) \rfloor = 6;$$

Easter Day (New Style) = (6 + 6 − 10) April = 2 April.

(2) Determine the Easter Day (New Style) for the year 1807.

$$a = R_7 (7 + Q_4\, 7 - 18) = R_7 (-10) = -3 \text{ or } 4;$$
$$\Delta = 2;$$
$$a' = R_7 (a + \Delta) = R_7 (4 + 2) = 6;$$
$$b = R_{19} (90 + 7 + 4) = R_{19} (101) = 6;$$
$$c = 30 - R_{30} (66) = 24;$$
$$\Delta_1 = 8;$$
$$c' = c + \Delta_1 - 30 = 24 + 8 - 30 = 2;$$
$$d' = R_7 \lfloor 7 - R_7 (8) \rfloor = 6;$$

Easter Day = (21 + 2 + 6) March = 29 March.

Just the same day, 29 March, 1807, the asteroid Vesta was discovered by Olbers. We can see from the preceding that all operations can be made on numbers of two digits. If we obtain in particular cases the numbers of three digits, $N = 100s + 10t + u$, the operations $R_9\, N = R_9 (100s + 10t + u)$, for $9 = 7$ or 19 can be performed on reduced numbers, because

* If $b - 4$ is negative, add 19.

$$R_7\,(100s + 10t + u) = R_7\,(10t + u + 2s);$$
$$R_{19}\,(100s + 10t + u) = R_{19}\,(10t + u + 5s).$$

If $R_7\,(10t + u + 2s)$ or $R_{19}\,(10t + u + 5s)$ are themselves numbers of three digits, we can reduce them again by the preceding formulas.

In formulas (1–13) the second reduction is never needed.

ST. PETERSBURG, RUSSIA,
26 July, 1899.

LIFE ON OTHER WORLDS.

D. T. MACDOUGAL.

Some of our neighbors in the solar system, particularly Mars, are said to exhibit well-delimited areas which increase in size, and undergo variations in color, corresponding with the seasonal changes of the planet on which they occur. Repeated observations of this character have been a most fruitful source of discussion among astronomers; and many, in fact, deny the accuracy of the investigations detailing the existence of, or changes in, the bands, belts, or "canals" on members of the solar system. It is not for the layman to sit in judgment upon this lack of harmony in the celestial choir, except perhaps to take note of the arguments of biological import used in the controversy.

An examination of the results of observations of the canals of Mars, made continuously throughout an entire year by the staff of one of the best equipped stations in the world, goes far to weaken such denials. The mere rehearsal of the many theories which have been advanced in interpretation of the belts or canals of Mars would carry the present article far beyond its intended limits; and if the semi-scientific literature upon the subject were included, an extensive excursion into the regions of humor and phantasy would result.

The increasing attention paid to this biological phase of astronomical work has brought about the reference of many incidental questions to the physiologist; and it is to be said that the evidence at hand, consisting chiefly of the facts mentioned above, affords but slight foundation for demonstration or sound speculation as to life on other worlds. No more should be expected than that the biologist should outline the more important properties of living matter, and project these into the conditions existent on other planets; though it is by no means to be as-

sumed that the structure or organization of protoplasm is identical throughout the universe. A statement of the generalized properties of terrestrial living matter will afford a convenient basis of discussion of such evidence as may, from time to time, be brought to our attention by the astronomer.

The protoplasm of terrestrial plants and animals is a more or less fluid substance, which varies in consistency from that of the white of an egg to the hardness and brittleness of a seed. The fluidity is due to the presence of water; and the amount of liquid present depends upon the degree of development or activity of the organism of which it forms a part. Thus, the quiescent protoplasm of seeds contains 5 to 15 per cent of water; while actively growing tissues of plants or animals may hold as much as 90 or even 99 per cent. Living matter is not a solution in a physical sense, but consists of the more fluid portion of fairly homogeneous structure in which are embedded numbers of bodies of widely differing physical and chemical properties. These bodies are centers of physical, chemical, and physiological activity. The complex interplay of forces set free here and in the imbedding stroma constitutes the phenomena termed *life*. Fluidity must be an indispensable property of any type of living matter which we are able to imagine; but it need not be due to the presence of water. This might be replaced by any other substance liquid at ordinary temperatures prevalent on the planet upon which it occurs. In such instances, the degree of fluidity would be dependent upon a set of conditions entirely different from those of the Earth.

Terrestrial protoplasm shows, by chemical analysis, the invariable presence of twelve elements of low atomic weight, which were presumably formed early in the history of the universe. These elements are carbon, nitrogen, sulphur, hydrogen, oxygen, phosphorus, chlorine, potassium, sodium, magnesium, calcium, and iron; and they must, doubtless, play an important part in the construction of living matter everywhere. It is not to be assumed that all of these should necessarily be included, nor that others of lower or higher atomic weight might not take part. In general, it might be said that the factors determining the elements entering into the existence of any protoplasm would be determined by the age, atomic weight, and abundance of those present. The possibility that the elements may exist elsewhere with different properties from those with which we are acquainted must also be considered. That other elements may take an important part in the construction of living matter is

suggested by the fact that silicon, fluorine, bromine, iodine, aluminum, and manganese are also found as occasional constituents.

In order to exhibit an activity which might in any sense be comparable to that of the living matter with which we are familiar, it would be necessary to have the included elements built up into several complex compounds of high molecular complexity which would not be totally inactive to one another, and the chemical activity of which might be easily influenced by external factors, such as temperature. Furthermore, one or more of the compounds should unite readily with a disintegrating agent of wide distribution, which union would set free the stored-up energy. The disintegrating agent might be present in the atmosphere or in the substratum. Oxygen of the air performs this office on the earth; and the process constitutes respiration. Respiration is a breaking-down process, or destructive metabolism; and its products are heat, mechanical forms of energy convertible into work, and elements or simple compounds. The last may be excreted or retained by the organism.

The construction of the complex compounds of which protoplasm is composed must be accomplished by means of energy derived from some source external to the organism. The source of that used by terrestrial organisms is the food consumed, together with a certain amount of heat, light, and electrical or magnetic energy. When the food consumed consists chiefly of complex decomposable substances, the amount of radiant energy used is very small, as in the case of most animals and many plants. When the food is of comparatively simple substances, the amount of radiant energy used is often very large, as in the case of green plants which need much sunlight for their development. Plants accumulate a great amount of complex material by means of this energy; and essentially they are constructively metabolic organisms. Animals use the complex material constructed by plants for food, are destructively metabolic, and may be said to be parasitic upon the vegetable kingdom. The activities of these two branches of the living world theoretically equalize each other; but, according to all data at hand, the products of the plant world far overbalance those of animals in all particulars.

Thus, it is customary to speak of the maintenance of the composition of the atmosphere by the opposing action of plants and animals; plants giving off oxygen and absorbing carbon dioxide, and animals carrying on the reverse processes. As a matter of

fact, the physical or, more particularly, geological combination and liberation of these substances render the total product of the living world of comparatively little importance. It is conceivable that all of the organisms of any system might make large use of radiant energy as plants do and, at the same time, attain a development corresponding to that of animals. The differentiation of living things into plants and animals is, therefore, an incident in terrestrial natural history, not a universal necessity.

The nature of the activity of protoplasm demands that it should take in a more or less constant supply of matter from the substratum of surrounding medium, and build this matter up into the compounds of which its body is composed, excreting material of no further use to it. Terrestrial protoplasm accomplishes this by the ingestion of solid particles of the desired substances, or chiefly by the osmotic absorption and excretion of fluid solutions. Incidentally the chemical union with the limiting membrane of the substances absorbed by it, and their liberation in the original form in the interior, as well as the passage of compounds in divided form or as separate ions, electrolytic effects, and electric currents, may play a more or less important part in the absorption of food-substances.

One or more of the last-named methods may become the principal one or ones in the accession of food- or building-material in extra-terrestrial organisms. The absorption and assimilation of more material than is consumed in respiration implies an increase in the bulk or weight of an organism. The increase, or growth, as it is termed, may continue until the volume bears a certain proportion to the surface, determined by gravity, the substratum, the surrounding medium, the atmosphere, and the specific constitution of the organism or given mass of living matter. Hence, no inference can be made of the size of organisms elsewhere in the universe, since each of these factors plays a variable part.

An essential characteristic of living matter is its capacity for response to environmental variations by changes in the form, size, structure, composition, and degree of activity of the organism into which it has developed. It is of the greatest importance that it should be able to undergo such physical alterations as will enable it to endure conditions unfavorable to growth and activity. Thus, terrestrial protoplasm has the power of ridding itself of a large proportion of its water upon the approach of a cold season or of an extremely warm environ-

ment. The alternation of favorable and unfavorable seasons, such as summer and winter, or wet and dry periods, on the Earth's surface has resulted in stamping upon protoplasm the habit of moving in cycles. Summer and winter do not necessarily correspond to seasons of growth and of rest, respectively, throughout the universe. It is quite conceivable that the season of high temperature might be the resting-period of the organisms on any planet, and that the winter would furnish the most favorable conditions for the activity of the living matter. Again, the formation or acquisition of food-material and growth might take place in separate seasons.

The recurrence of unfavorable seasons for activity tends to induce the formation of specialized reproductive bodies, in which form the animal or plant may endure greater extremes of temperature, etc. This fact is much more prominent in the vegetable than in the animal kingdom. Other factors, of course, enter into the necessity for the production of spores, egg-cells, seeds, and eggs; but it is not unreasonable to suppose that the sexual phase and specialized reproductive bodies might be entirely lacking in the systems of organisms on any world. The formation of new individuals might result from budding, essentially simple growth, in the same manner as new plants arise from runners or offsets, or as a gardener grows his stock from cuttings consisting of leaves or bits of stem. Similar occurrences are frequent among the lower unimals; and a writer of fiction, in a recent discussion of the inhabitants of Mars, brings about their multiplication in this manner.

The form and structure of an organism must depend directly upon the factors constituting its environment; and terrestrial life should not be taken to resemble that of other worlds. It has been pointed out that the organisms of any planet would not necessarily be divided into plants and animals; and even if such were the case, the resultant forms could have only the most remote resemblance to terrestrial forms. The similarity of two systems of living things derived from unlike beings, and coming through untold ages of development under the most widely different conditions on separate planets, would be absolutely impossible.

Concerning the existence of life elsewhere in the universe, it is to be remembered that the general physical condition of an extra-terrestrial body must be taken with great caution as the index of the presence or absence of living things. The protoplasm of resting seeds may withstand the cold of liquid air nearly 200°

Centigrade below the freezing point, or more than 300° below zero Fahrenheit. These seeds and spores of bacteria live and grow after being subjected to a temperature of 125° Centigrade, or nearly 260° above zero Fahrenheit. It is thus to be seen that terrestrial protoplasm is capable of an adjustment to a range of temperature of 325° Centigrade, or nearly 600° Fahrenheit. In view of these facts, it would be extremely rash to say that complex masses of matter constituting a protoplasm might not exist at temperatures much above or below those of the earth. The range of endurance would depend upon the liquid entering into the composition of the living matter in question. The extremes of temperature given above were produced artificially, of course. With the exception of the heats of volcanoes, thermal springs, and lightning flashes, they are not produced on the earth's surface; and plants have had no opportunity of acquiring special adaptations toward the endurance of such extremes. A temperature equal to that of the sun, where the elements are more or less separated into layers, and where the molecular velocity is very great, would form an absolute upper limit to life, though the actual limit would be far below this point. Absolute zero, or 273° Centigrade below the freezing point, would form a lower limit, though periodic recurrences of this temperature would by no means form a barrier to life.

The presence of an atmosphere, even intermittently, is not necessary to life, although the presence of the liquid to which the fluidity of the living substance would be due would imply the presence of a more or less attenuated atmosphere. The respiratory or disintegrating agent might be present in the substratum or nutritive medium. Among terrestrial organisms, the anaerobic bacteria are instances of plants which not only do not need an atmosphere, but actually perish in its presence, or in one of its constituents, and live deeply immersed in the bodies of other plants or of animals with which their presence is always associated. The absence of a permanent gaseous envelope, or fluid medium, would render impossible the development of any but fixed forms, attached firmly in place like typical plants. Such conditions would be eminently unsuitable for locomotor organisms resembling animals, although such types might exist by means of special adaptations for storing the respiratory agent.

Great stress has been laid upon the colors of the bands or canals of Mars, in the discussions as to the probability that these areas may be zones of living organisms. It is to be seen from the above that a comparison with the colors of terrestrial vegetation

is practically meaningless. The green coloring matter of plants is due to a substance which serves the purpose of a screen in absorbing rays of light and in converting them into heat and other forms of energy, It does seem probable that light would be the most available source of energy for living bodies on all planets more distant than the Earth from the Sun; yet the absorbing screen, in any instance, might take up almost any portion of the visible or invisible rays, and reflect any color. Then, if the invisible rays alone were absorbed, color would be of even less significance in the interpretation of planetary markings. Periodic variations of the color of such markings are, however, of great importance as indications of life, when taken in connection with other groups of facts. Special mention is made of the matter of temperatures, atmospheres, and color, since these are the criteria used by astronomers in discussing the possibility or probability of extra-terrestrial life.

The primary purpose of this paper is not to declare or deny the existence of organisms on other bodies besides the Earth, but rather to call attention to the limitations of such life, if it does exist. A consideration of all data at hand leads to the conclusion that extra-terrestrial life is quite within the range of possibility, and, indeed, seems highly probable. Up to this date, however, actual demonstration of phenomena which would change the probability into a well recognized fact has been but scanty. We may look with the greatest hope to the investigations now in progress upon the surface-markings of Mars for the all-important evidence. Positive proof that life is not to be found on that planet would only leave the main question open to determination by observations upon other bodies within the range of our means of research.

The determination of the presence or absence of life on other members of the universe presents a most fascinating problem to the planetary observer, and affords to the biologist a most alluring field for speculation. The subject will doubtless claim an increasing amount of attention from the votaries of both branches of science, and will attract a large share of popular interest.

Sun-Spot Drawings.—A series of 44 large quarto plates of Sun-spot drawings by Father Benedict Sestini, S. J., of the Georgetown College Observatory, Washington, D. C., in 1850, is received. It is a beautiful piece of work.

STAR NAMES AND THEIR MEANINGS.

WM. W. PAYNE.

The title chosen for this review belongs to a new book written by Richard Hinkley Allen, of Chatham, New Jersey, and published by G. E. Stechert, of New York. It is on sale in Leipsig, London and Paris.

Star-names and their meanings is a most difficult theme to present in definite and satisfactory way, because of the obscurity and the uncertainty of the early history from which they have come into astronomical science. The task of writing such a book as this is made doubly hard, when one remembers that some of these very old star-names are derived from words in the ancient Hebrew and Arabic languages whose roots consisted of only two letters. The changes of meaning through which words of every language pass in the process of time make it quite impossible for the scholarly linguist to decide what was the exact meaning of many of them in very early times. As an illustration of this the names of the constellations, Taurus, Gemini, Cancer, Libra and some others which are from the Latin are accounted for by Semitic roots, consisting of only two characters. It is also a fact which scholars know that roots of more than three characters may be equally uncertain.

These things are merely mentioned to call attention to a few of the many things of similar kind that stand in the way of obtaining definite knowledge of the real meaning of star-names if we consult the very best sources of information now open to investigation.

We think Mr. Allen, the author of this new book, was wise in not attempting to collate authorities and opinions respecting the meaning of star-names, when considered largely from a linguistic point of view. Such a step involves the great difficulties just alluded to. Few of the best scholars in the ancient languages have undertaken this task, except in a fragmentary way, and, hence, this whole field is still waiting for students who are able to traverse it because they have the requisite linguistic preparation for the work.

In his introduction, the author mentions the names of great scholars who have been interested in the history of the constellations, such as Grotius, Scaliger, Hyde, Whitney, Thomas Hood, Thomas Carlyle and others, and then refers to the legends and myths of early writers, and something of the relation of

these to the history of these asterisms in all centuries that have furnished accessible records. This work must have involved great labor and pains-taking care to find the information wanted and then to relate it so well in a consecutive account.

The author really begins the work in hand by brief notices of the zodiacs, solar and lunar. The solar zodiac is referred to by Riccioli who gave its Chaldean title and references to it as early as 3880 B. C., and Professor Sayce, of Oxford, remarks that the calendar was probably taken from the stars about 2000 B. C. The Chaldeans passed it to Assyria and thence it went to Aramaea, and to the Jews, who for a time made the stars objects of idolatrous worship, as is evident from their history detailed in the 2d Book of Kings, xxiii: 5.

Among the other references of the solar zodiac are the Babylonia Epic of Creation discovered by George Smith in 1872 which dates back 600 B. C., though probably originally composed as early as 2350 B. C. and confirmed by a tablet bearing date 2140 B. C.; a number of interesting references to early Jewish history; notes on the Arabian zodiac; its twelve parts as known to the Greeks as early as 500 B. C.; at later times references by the Latin writers including Bayer's name for the zodiac which means little images; later still are references of the English writers, such as Chaucer, Milton and Pope, and finally a reference to the Chinese zodiac whose symbols mark the twelve months of the year and whose origin is of uncertain date, between 700 B. C. and 2700 B. C.

In this article on the Solar Zodiac, the names by which it was known at different times by different nations the world over, are all printed in heavy-faced type so that the eye will immediately catch them as the pages are glanced over. This is a capital idea, for it furnishes an easy index on every page, and the rapid reader will be saved much time by the simple and useful device.

From a study of the few pages embraced in this article, the reader learns how important the idea of the solar zodiac must have been in the thought of almost every nation on the Earth, and that its form was generally one of animals. The author, also, calls attention to the fact that the twelve figures of the zodiacal circle were worked into the walls and pavements of early churches, cathedrals and public edifices, as well as sometimes in private houses. This is now seen in the East, and it was observed in one of the exposition buildings in 1893 at Chicago, although not well done the general effect was pleasing. The next article is titled The Lunar Mansions which treats of

the asterisms which lay along the celestial equator, or in the zodiac. They are usually 28 in number varying in length, though theoretically they were supposed to represent the length of the Moon's path in the sky each day as it moves around the Earth in its orbit during a lunar month.

In this connection the author brings out much of interest concerning the lunar mansions, as probably preceding in time the solar zodiac, and the constellations generally. References are made to knowledge of them in India, China and Arabia, in a way to suggest the probability of earliest attempts in the formation of a kind of stellar science. They were studied in these very early times probably for the purpose of knowing what might be learned for uses in astrology. The author points out the astrological character of these lunar mansions, indicating which were esteemed fortunate, the unfortunate ones and those which were uncertain; but the most important feature to which he calls attention is their antiquity. That he claims is proved by the fact that the list began with the Pleiades when those stars marked the vernal equinox, and also by the fact that many of their titles are found in old books by the Chinese which bear date about 2500 B. C. As might be expected these mansions, as located by different nations, are not always in agreement one with another, but in the case of several this is true.

The next topic is the constellations which occupies the greater part of this interesting volume. This delightful theme is first treated from the historical side, beginning with the Greek and Latin authors, noting the work of Hipparchus and Ptolemy; Ulug Beg, Bayer, Copernicus and Tycho Brahe, and so along down to the times of the modern authors who have given attention to the study of the constellations in the way of catalogues, charts and maps pointing out the changes that have taken place in boundaries, names and other minor details. This part of the theme is well and carefully presented and we have read it with profit. The next step in the study of the constellations is to ascertain the dates of formation and the places of origin of the earliest of the sky-figures as we now know them. Although many countries lay claim to this honor the author thinks we may well agree with Laplace that their forms and names have not been given by chance. In this sentence is more meaning than at first thought appears. The author first mentions Aratus, the Greek poet who first wrote on astronomy, of books now extant, claimed that their origin was in most ancient times. His sphere is said to be identical with that of Eudoxos which was a

century earlier in time, and which is said to represent well the heavens at a date of about 2000 B. C. If this be true the poem of Aratus is certainly very valuable literature, although Hipparchus and Cicero criticized it in some degree justly, yet our author speaks rightly of the prominence of Aratus' poem when he says, it had thirty-five Greek commentators, and that it continued to be used as a practical manual of sidereal astronomy as late at the 6th century of our era.

Just when and where the origin of the 48 old constellations should be placed is unknown. The author has made this point clear, and at the same time has stated quite fully the claims of Pliny, and of others who think their origin was Egypt, and that Greek scholars obtained their knowledge from that source, and by them was conveyed later to the European nations. He also gives the views of others who speak of the early Chinese figures which consisted of 28 and the 12 zodiacal groups of stars, and the names by which they are known in heavy-faced type. He also mentions Ideler who asserted in 1815 that the constellations originated on the Euphrates, and quotes this significant phrase: "reduplications of simpler ideas connected with natural phenomena," whatever that may mean. This seems a little obscure without the connection since it is said "that the conviction as to the truth of this seems to be growing among the students of stellar archeology." It was not probably deemed important enough to the author to say more about it, since original sources of information are plainly cited. The views of later writers concerning the origin of the old constellations follow in the same general way as indicated in previous topics. The third general division of this theme relating to the origin of the old constellations is that which some call the Biblical school and the Mosicists who sought interpretation of them from sacred history. The easliest mentioned by the author was the Venerable Bede, and the next, Giordano Bruno of the 16th century who sought to substitute moral virtues for the ancient figures. The author rightly thinks that these efforts have failed in signal way, as might almost have been expected. He then speaks of the later work of Miss Frances Rolleston and that of Dr. Joseph A. Seiss as "especially remarkable." He refers without name to Miss Rolleston's Mazzaroth, and Dr. Seiss' work is almost wholly drawn from Mazzaroth. His characterization of the last named book is not overdrawn. It is certainly the most remarkable book on this theme which we know of in the English language, and yet in this country, at least, it has received less attention

than it deserves, by far, if we have formed the right opinion of it. Its chief merit lies in its linguistic research, which to us, seems very convincing. We are not aware that its positions have been discredited by any scholar either in language or science. As we have before said, the author of this book has not considered this branch of study of the star-names. After some references to map-work of the constellations by the well-known authors, such as Hipparchus, Ptolemy, Dürer, Bayer, Flamsteed, Argelander and Heis, the author quotes from the writings of classical authors whose varied and poetical allusions to the stars pleasantly relieve the taxed attention of the reader when thought is busy on so much interesting historical detail, in the general discussion of this theme which covers the first 31 pages of the book.

After this the constellations are taken up in order, and presented quite fully on the same plan as indicated in the topics already considered. Andromeda is the first and nine pages is devoted to the description of it, adopting somewhat the method used in Webb's Celestial Objects, which book is probably known to most of our readers.

It is quite impossible to give a general idea of this part of the book to those who are not acquainted with the book just referred to, because each constellation consists of so much of interesting detail in its study that what is said of one will not very well apply to another. The best way we can think of it is to give a brief illustration of a part of one of the constellations. For example, α Lyrae, may suffice for this purpose. Below the first fourth of the description of this star, on pages 284 and 285, is copied:

α, 0.3, pale sapphire.

Wega, less correctly **Vega,** originated in the *Alfonsine Tables* from the Wāki' of the Arabs, Bayer having both titles; Scaliger, **Waghi;** Riccioli, **Vuega** *vel* **Vagieh;** and Assemani, **Veka.**

The Greeks called it Λύρα, which, in the 16th-century *Almagests* and *Tables*, was turned into **Allore, Alahore,** and **Alohore.**

Among Latin writers it was **Lyra,** in classical days as in later, seen in the *Almagest* of 1551 as *Fulgens quae in testa est & vocatur Lyra;* and in Flamsteed's *Testa fulgida dicta Lyra;* but Cicero also used **Fidis** specially for the star, as did Columella and Pliny **Fides** and **Fidicula,** its preëminent brightness fully accounting for the usurpation of so many of its constellation's titles, indeed undoubtedly originating them. In Holland's translation of Pliny it is the **Harp-star.**

The Romans made much of it, for the beginning of their autumn was indicated by its morning setting. It was this star that, when the hour of its rising was alluded to, called forth Cicero's remark, "Yes, if the edicts allows it,"—a contemptuous reference to Caesar's arbitrary, yet sensible, interference with the course of ancient time in the reformation of the calendar, an interference that occasioned as much dissatisfaction in his day as did Pope Gregory's reform[1] in the 16th century.

Sayce identifies Wega, in Babylonian astronomy, with **Dilgan,** the Messenger of Light, a name also applied to other stars; and Brown writes of it:

> At one time Vega was the Pole-star called in Akkadian **Tir-anna** ("Life of Heaven"), and in Assyrian **Dayan-same** ("Judge of Heaven"), as having the highest seat therein;

but fourteen milleniums have past since Wega occupied that position!

[1] The English refused to adopt this reform till 1752, when they abandoned the Old Style on the 2d of September, and made the succeeding day September 14th, New Style: a change, however, that "was made under very great opposition, and there were violent riots in consequence in different parts of the country, especially at Bristol, where several persons were killed. The cry of the populace was 'Give us back our fortnight,' for they supposed they had been robbed of eleven days."

Following the constellations is a brief description of the Milky Way, and the full general indexes close the volume of 547 pages. The printing is handsomely done, the indexes are full and arranged in varied type to be read with perfect ease. The work as a whole is creditable to all who have been concerned in its production, and it ought to find ready sale on its merits. Price $5.00.

Send to G. E. Stechert, the publisher, New York and London.

SPECTROSCOPIC NOTES.

Professor Bunsen died at Heidelberg, August 16. Famous as the inventor of the Bunsen burner in use in every laboratory, of the Bunsen photometer, the Bunsen battery, and the Bunsen calorimeter, and illustrious preëminently as the originator, jointly with Kirchhoff, of spectrum analysis yet probably few readers are aware that Prof. Bunsen has been living until so very recently in Heidelberg at an advanced age and in feeble health.

Robert Wilhelm Bunsen was born March 31, 1811, at Göttingen, where his father was professor of theology in the university. There he graduated at an early age, submitting a thesis on the subject of hygrometry. At twenty-two he was privat-docent. In 1836 he became professor of chemistry in the Polytechnic

school at Cassel. In 1838 he was appointed to the chair of chemistry in the University of Marburg, remaining there thirteen years. After a short time at Breslau, in 1852 he accepted the chair of chemistry at the University of Heidelberg, which he occupied for about thirty years, and with which his fame as an investigator and success as a teacher are chiefly associated. About twenty years ago he retired from the active duties of the position, continuing to reside in Heidelberg till his recent death at the advanced age of eighty-eight.

Professor Bunsen's earlier investigations related to subjects distinctly chemical; in particular, one with a poisonous and explosive gas ended in an accident almost fatal, resulting in the loss of the sight of one eye. In 1838 he proved that in blast furnaces there was an enormous amount of valuable fuel going to waste in the gases, now utilized. In 1841 he devised his battery by substituting carbon for the platinum pole of the Grove cell. His famous work on the theory of geysers was the result of a visit to Iceland in 1847.

His epoch-making work in the founding of spectrum analysis, executed in conjunction with his colleague Kirchhoff, professor of physics in the University of Heidelberg, was done in 1858-60, and the consequent revolution in at least three sciences ensued within a very few years. Their detection of unappropriated lines in the solar spectrum, and Professor Bunsen's discovery of two new metals of the alkaline group in a persevering and successful attempt to find the source of the lines, by evaporating forty tons of Dürkheim mineral water to get 16.5 grammes (half an ounce) of the combined chlorides of the new Caesium and Rubidinum, constitute one of the romantic feats of what some people like to term prosaic science.

Hidden away in a dark shelf (and the prisms arranged with their refracting edges inward!) the original spectroscope of Kirchhoff and Bunsen—a few may have been fortunate enough to see it—was included in the German educational exhibit, at Chicago in 1893.

A number of astronomers, most of them amateurs, seem to have joined in the expedition of the British Astronomical Association to the total eclipse of Jan. 1897, in India. Among the rather diversified results it is interesting to notice that they confirm a big correction to the coronium line, detected by Mr. Fowler from photographs obtained by Sir Norman Lockyer's party at the same eclipse.

The report presented by Mr. Newall to the Syndicate of the University Observatory, Cambridge (England,) states that during the year ending May 19 the work of photographing star spectra to determine motion in the line of sight has gone on actively; that the spectroscope is being altered to admit of a detailed study of the spectra of the brightest stars; and that an exhaustive discussion is in progress of the photographs of the spectrum of the sun's limb obtained at the eclipse in India, including an examination of the spectrum of the rare metal scandium.

In his study of the spectra of stars characterized by the presence of strong helium lines Sir William Huggins now adds to his confirmation of Mr. McClean's discovery of the presence of oxygen his own discovery, equally important, of the presence in some of them of the element nitrogen (*Astronomische Nachrichten*, No. 3583). In the spectra of Bellatrix, Rigel, and some others of the class, he finds a strong line in the position of the strongest line of nitrogen at $\lambda 3995$ in the extreme violet; in the spectrum of Bellatrix, further, he detects lines

corresponding with other strong lines on nitrogen. He regards it as highly probable that nitrogen is really present.

Dr. Gill, observing at the Cape of Good Hope, where Mr. McClean discovered the presence of oxygen in the helium stars, expresses his confirmation of the existence of oxygen in the strongest terms; and adds, though a little doubtfully, that carbon seems to be present.

It is stated that the new observatory and great refractor of the Astrophysical Observatory at Potsdam were inaugurated Aug. 26 in the presence of the German Emperor.

It is interesting to note that the new Algol-type variable star in Cygnus recently detected by Madame Ceraski, which is found to have a larger light-variation than any previously known of its class, is yet no exception to the rule that an Algol-type variable shall have a spectrum of the first, or hydrogen, class.

In an article of considerable length in the *Astrophysical Journal* for August Professor Hale and Mr. Ellerman give the first instalment of the description of their interesting and difficult study at the Yerkes Observatory of the spectra of stars of Secchi's fourth type. This work was selected for the 40-inch telescope because with these faint stars great light-gathering power is essential, and because a visually corrected object glass is suitable, used with isochromatic plates, for these stars, which are very weak in violet light. The spectrograph used has three dense flint equilateral prisms, giving a deviation of nearly 180°; the yellow tinge of the glass of the prisms being immaterial in this case, as only the yellow, green and blue of the spectra are photographed, not the violet. They describe in detail the measurement of the plates and the method of reducing the measures. At the end of the paper they contend strongly that bright lines are really present in the spectra of these stars.

The irregularities in the motion of the line of sight of the spectroscopic binary α^1 Geminorum Herr Belopolsky has sought to explain by a motion of the line of apsides of its orbit. Using three groups of photographs of its spectrum taken in as many years he finds that the revolution of the line of apsides is real, and takes place in about four years, while the period of revolution of the binary itself is 2.93 days. The cause of the motion of the line of apsides he considers to be a flattening of components; if the system has the dimensions of Algol an oblateness of one-seventh would be adequate.

In the official report of the Observatory at the Cape of Good Hope it is stated that the 24-inch photographic object-glass is defective in having its color correction for a point toward the red from the Hγ line in the violet, instead of at Hγ; this defect it is understood the maker will remedy.

In the *Astrophysical Journal* for August Dr. Wilsing of Potsdam describes his attempts to reproduce by artificial means the typical spectra of new stars. In the spectrum of Nova Aurigae pairs of lines occurred, consisting each of a bright line, with a dark line close to it at the side toward the violet. These were explained by assuming two components for the Nova with different velocities in the line of sight; but the enormous velocities required (500 to 800 miles per

second) seemed such as to discredit this explanation. Observations of Nova Normae (1893), as well as of β Lyrae and P Cygni have shown clearly the need of another explanation. Dr. Wilsing bases his explanation on the shift of the lines of the spectrum with change of temperature as observed by Paschen, and with change of pressure as observed by Humphreys and Mohler. The latter have found, at a pressure of twelve atmospheres and less, a slight displacement toward the red, proportional in amount to the pressure; for the Nova a pressure of several hundred atmospheres would be required. Dr. Wilsing investigated the character of the spectrum resulting from a bright spark discharge between metallic electrodes under water, where molecular tensions are presumably such as to be equivalent to a very high pressure in gases. He was successful in producing spectra resembling that of Nova Aurigae. He proposes, therefore, as a plausable explanation of the peculiar spectrum of the Nova, the assumption of a photosphere under considerable pressure, superposed by an absorbing layer or atmosphere under small pressure.

VARIABLE STARS.

J. A. PARKHURST.

Maxima and Minima of Long Period Variables.

1899 December.

	MAXIMA.	Mag.	Day.
294	W Cassiopeæ	8 6	14
419	U Andromedae	8.9	25
1357	U Eridani	8.5	21
1623	T Camelopard.	7.0	14
1761	R Orionis	8.7	17
1771	R Leporis	6-7	30
1803	T Leporis	8.1	7
2013	U Aurigae	8.6	17
2946	R Cancri	6.0	23
3881	V Hydrae	6.7	19
3994	S Leonis	9.0	32
4492	Y Virginis	9	17
4596	U Virginis	8	2
4896	T Centauri	5.9	7
5752	RZ Scorpii	6	19
6608	RV Sagittarrii	8 2	18
7220	S Cygni	8.8?	19
7538	RR Capricorni	9	31
7571	V Capricorni	9	2

	MAXIMA, Con't.	Mag.	Day.
7779	S Cephei	7.4	4
7994	R Piscis aust.	8.5	25
8562	Z Aquarii	8.2	16
8591	V Cephei	6.2	17
8622	W Ceti	8.4	11
	MINIMA.		
906	R Trianguli	11.7	7
1222	R Persei	13.5	16
1717	V Tauri	<13.5	15
1855	R Aurigae	12.7	31
2258	V Aurigae	<11.5	9
2684	S Canis minoris	12	25
3493	R Leonis	10	12
4521	R Virginis	11	22
5494	S Librae	<13	16
7120	χ Cygni	13.5	24
7085	RT Cygni	11	11

Minima of the Variable Stars of the Algol Type.

(Given to the nearest hour in Greenwich Time.)

U CEPHEI.			λ TAURI.			S CANCRI.			DM + 12°3557		
	d	h		d	h		d	h		d	h
Nov.	3	13	Nov.	1	17	Nov.	2	23	Nov.	3	10
	8	13		5	16		12	10		8	18
	13	13		9	15		21	22		11	10
	18	12		13	14	W DELPHINI.				16	18
	23	12		17	12		d	h		19	10
	28	12		21	11	Nov.	18	16		24	18
				25	10		23	11		27	11
				29	9		28	6			

ALGOL.			S VELORUM.			R CANIS MAJ.			DM + 45°3062		
	d	h		d	h	Every 8th min. $P = 1^d\ 3^h.3$				d	h
Nov.	7	23	Nov.	2	20		d	h	Nov.	1	18
	10	20		8	18					6	8
	13	17		14	17	Nov.	9	11		10	22
	16	14		20	15		18	13		15	11
	19	11					27	15		20	1
	30	22								24	15
										29	5

The minima of + 45°3062, the new Ceraski Algol-type star, are given 1^h later than the above times by Professor Pickering in H. C. O. Circular No. 44.

THE PERIODS OF SOME OF THE VARIABLE STARS IN THE CLUSTER MESSIER 5. A paper with the above title by Professor S. I. Bailey of Arequipa, Peru, was read by Professor Barnard at the Conference at the Yerkes Observatory Sept. 8. Of the 85 variables in the cluster Professor Bailey communicated data in regard to about 40, which were so nearly alike in magnitude, range of variation, period, and form of light curve, as to suggest for this form the title of the "Cluster Type" of variables. These stars are all within 11′ of the center of the cluster, the brightest is $13^m.4$ at maximum and the faintest $14^m.9$ at minimum. Their range of variation is about one magnitude, the least being $0^m.7$ and the greatest $1^m.4$. The periods are included between $0^d.400$ and $0^d.699$, averaging $0^d.526$.

In regard to the form of light curve, Professor Bailey says that it is quite uniform for all these stars, but that no such similarity exists for the numerous variables in the cluster ω Centauri. Details were given for four of the stars, the curve for one, No. 33, is reproduced here. The period is given as $0^d.500744$, and the range of variation from $13^m.6$ to $14^m.8$. As will be seen from the curve, the time of fall occupies 40% of the period, the normal light 50% and the rise 10%, the fall beginning again immediately after the maximum is reached.

An inspection of the curve at once suggests its resemblace to that of SS Cygni (and probably of U Geminorum), in fact they are almost identical in proportions except that the rise is more rapid in the case of SS. But even this lack of identity is fully supplied by Professor Bailey's report of his methods of observation, and by Professor Barnard's visual observations with the Yerkes 40-inch. The magnitudes used by Professor Bailey were all found from photographs taken with the 13-inch Boyden telescope with exposures of one or two hours. As pointed out by the author, such exposures, bearing so great a ratio to the whole period, will mask the variations to some extent and tend to "smooth out" the curve. For instance, an exposure of two hours, $0^d.08$, beginning at $0^d.42$ in the figure and ending at $0^d.50$, would give for the middle time, $0^d.46$, the integral of the light during that interval, or about 14.2 or $14^m.3$, a value more than $0^m.5$ too high; thus showing a rise even more gradual than in the figure. Professor Barnard found from visual observations that the rise took place in 15 or 20 minutes, or about 2% of the whole period. The above cause of difference between the visual and photographic results was pointed out by Professor Bailey in a paper read before the Conference. With this correction the duration of normal light becomes 58% of the period, and if a slight correction is made for similar reasons to the beginning, the duration can be taken as approximately 60% of the period. For SS Cygni the rise occupies about 2% and the normal light averages 68% of the period, a resemblance sufficiently close to link together the "U Geminorum" and the "Cluster" types.

SS CYGNI. The July and August maxima were well observed. I have at hand observations as follows:

	July Max.	Aug. Max.		July Max.	Aug. Max.
Zaccheus Daniel	14		J. A. Parkhurst	11	15
David Flanery	10	2	Wm. E. Sperra	11	10

Mr. Sperra was fortunate enough to secure two observations during the rise July 1, and I did the same during the rise Aug. 22, so the critical times are determined for both maxima within $0^d.1$.

The following resumé will show the most important results, the detailed observations will be published later.

	July Max.	Aug. Max.
Previous normal period	41^d	38^d
Rise began	July 1.0	Aug. 22.0
Passed 9^m 35	" 2.0	" 23.0
Interval since last rise	$51^d.2$	$52^d.0$
Maximum	July 3 8	Aug. 26.6
Interval since last maximum	60^d	$53^d.8$
Reached normal	July 15	Sept. 10
Above normal light	14^d	15^d
Correction to elements VII, 149	-10^d	-15^d

The observed magnitudes of both maxima were quite accordant, those by Mr. Flanery showing the greatest divergence, as he used a different set of magnitudes for the comparison stars, and as the individual comparisons were not communicated to me the observations could not be reduced to the same system with the rest.

LAST MAXIMUM OF MIRA. Professor A. A. Nyland (who, by the way, has lately succeeded Dr. Oudemans as director of the University Observatory at Utrecht, Holland,) has published in No. 3576 of the *Nachrichten* the light curve of Mira, with his observations from 1898 Aug 9 to 1899 Mar. 5.

He gives the following resumé of the last three maxima:

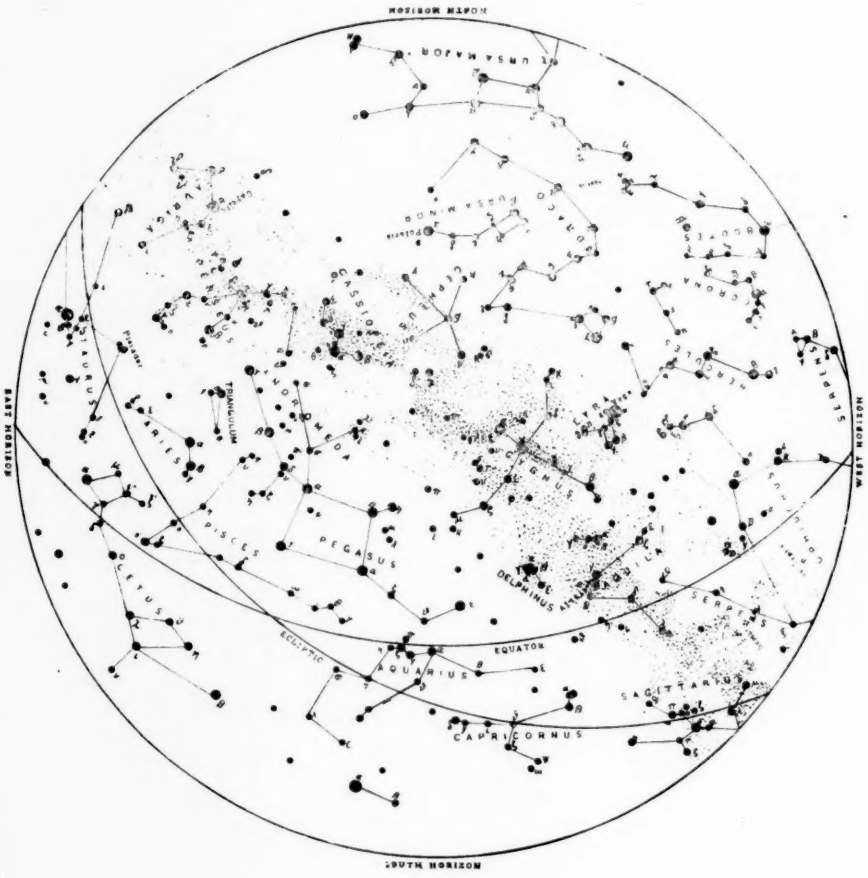
Obs. Max.	Chandler III Cat.	Cor.	Mag.	Period
1897 Jan. 11	1896 Dec. 13	$+29^d$	3.70	319^d
1897 Nov. 26	1897 Nov. 9	$+17$	3.24	312
1898 Oct. 4	1898 Oct. 6	-2	2.91	

COLOR CHANGES IN VARIABLES. Many observers have noted an increasing redness in certain variables as they approach minimum, while others doubted the existence of such a change, considering it as entirely subjective. Spectroscopic evidence of such change in Mira was noted from Rev. Sidgreaves' work in Vol. VI, page 354 of this journal. Photographic evidence pointing in the same direction is supplied by M. Edler von Kuffner of Vienna, in his annual report in Vol. 34 of the *Vierteljahrsschrift* page 177. He says "Of the variable stars, 102 exposures were made on β Lyrae and 52 on η Aquilae for the purpose of investigating the light changes of these stars. It was found that for β Lyrae the photographic and optical light changes were in complete agreement, but for η Aquilae the blue, photographic rays at minimum were reduced to one-quarter their maximum brightness, while the yellow, visual light only lost half its intensity. In form and phase the photographic and visual light curves agreed for both stars." As a result the redness of the latter star would increase as the minimum was approached.

PLANET NOTES FOR OCTOBER.

H. C. WILSON.

Mercury **and** ***Venus*** **have just passed superior conjunction and are hidden in the glare of the Sun. Toward the end of the month they may be visible in the southwest just after sunset, but not in position to be observed with any satisfaction. The two planets will be in conjunction with each other, Mercury 43′ south of Venus, on the 10th of October.**



THE CONSTELLATIONS AT 9 P. M., OCTOBER 1, 1899.

Mars and ***Jupiter*** are but a little way east of the Sun and so cannot be observed. They will be in conjunction with each other Oct. 11, and Jupiter will be in conjunction with Mercury Oct. 25 and with Venus Oct. 29.

Saturn and ***Uranus*** are also too low in the southwest for any observations after dark. There is thus a remarkable dearth of planets for the amateur astronomer to study during the month.

Neptune is the only planet in favorable situation and this is too faint to be observed except with a powerful telescope. It is to be found in the morning hours, among the faint stars nearly in line with and half way between ζ Tauri and η Geminorum.

The Moon.

	Phases.	Rises. (Central Standard Time at Northfield; Local Time 13m less.)	Sets. (Central Standard Time at Northfield; Local Time 13m less.)
		h m	h m
Oct. 4	New Moon	6 12 A. M.	5 21 P. M.
11	First Quarter	1 17 P. M.	10 40 "
18	Full Moon	4 57 "	7 33 A. M.
25	Last Quarter	10 52 "	1 30 P. M.

Occultations Visible at Washington.

Date. 1899.	Star's Name.	Magnitude.	IMMERSION. Washington M. T. h m	IMMERSION. Angle f'm N pt. °	EMERSION. Washington M. T. h m	EMERSION. Angle f'm N pt. °	Duration. h m
Oct. 21	τ Tauri	4.5	10 35	41	11 31	295	0 56
23	14 Geminorum	7.2	7 19	62	8 1	300	0 42

COMET NOTES.

New Comet *e* 1899 (Giacobini).—The following telegram was received at Harvard College Observatory from Professor Kreutz at Kiel Observatory, Germany, and was distributed to American astronomers Oct. 1:

A comet was discovered by Giacobini at Nice, Sept. 29 813 Greenwich Mean Time, in R. A. $16^h\ 26^m\ 3^s.2$ and Decl. $-5°\ 10'$. Daily motion in R. A. $+\ 2^m\ 0^s$; in in Decl. $+\ 0°\ 10'$.

Later telegrams state that Comet *e* 1899 was observed by Cohn at Königsberg Oct. 1.2767, Greenwich Mean Time, in R. A. $16^h\ 31^m\ 0^s.7$ and Decl. $-4°\ 39'\ 50''$, and again by Perrine at Lick Observatory Oct. 2.6658, Greenwich Mean Time, in R. A. $16^h\ 32^m\ 59^s.7$ and Decl. $-4°\ 12'\ 18''$.

Ephemeris of the Comet Tempel$_2$ 1899 *c* (1873 II).

1899	α app. h m s	δ app. ° ′ ″	log Δ	Aber. m s	$1:r^2\Delta^2$
Oct. 3	22 19 17.2	− 34 7 1	9.85541	5 57	0.802
4	20 47.8	33 56 13	86102	6 2	
5	22 18.5	33 45 4	86662	7	
6	23 49.4	33 33 37	87221	11	
7	25 20.5	33 21 52	87780	16	0.706
8	26 51.8	33 9 49	88338	21	
9	28 23.2	32 57 30	88895	26	
10	29 54.7	32 44 55	89451	31	

1899	α app.			δ app.			log Δ	Aber.		1:$\gamma^2\Delta^2$
	h	m	s	°	′	″		m	s	
Oct. 11	22	31	26.4	− 32	32	4	9.90006	6	36	0.622
12		32	58.2	32	18	58	90560		41	
13		34	30.1	32	5	39	91112		46	
14		36	2.2	31	52	6	91663		51	
15		37	34.4	31	38	20	92213	6	57	0.548
16		39	6.6	31	24	23	92761	7	2	
17		40	39.0	31	10	14	93308		7	
18		42	11.4	30	55	54	93853		13	
19		43	43.8	30	41	23	94397		18	0.483
20		45	16.3	30	26	43	94939		24	
21		46	48.9	30	11	53	95480		29	
22		48	21.4	29	56	53	96019		35	
23		49	54.1	29	41	45	96557		40	0.426
24		51	26.7	29	26	29	97093		46	
25		52	59.4	29	11	5	97627		52	
26		54	32.2	28	55	34	98160	7	58	
27		56	5.0	28	39	55	98691	8	4	0.376
28		57	37.9	28	24	9	99220		10	
29	22	59	10.8	28	8	17	9.99748		16	
30	23	0	43.7	27	52	18	0.00274		22	
31		2	16.7	27	36	14	00797		28	0.333
Nov. 1		3	49.8	27	20	5	01319		34	
2		5	23.0	27	3	50	01839		40	
3		6	56.2	26	47	30	02357		46	
4		8	29.4	26	31	7	02873		52	0.295
5		10	2.7	26	14	39	03387	8	59	
6		11	36.0	25	58	7	03899	9	5	
7		13	9.4	25	41	32	04409		12	
8		14	42.9	25	24	53	04916		18	0.261
9		16	16.4	25	8	12	05422		25	
10		17	50.0	24	51	28	05925		31	
11		19	23.6	24	34	42	06426		38	
12	23	20	57.2	− 24	17	53	0.06925	9	45	0.232

GENERAL NOTES.

An unusual delay in the issue of this number is caused by a needlessly slow shipment of paper. We hope to have next number nearly on time.

Chart for Leonid Meteor Radiant.—We enclose with this number of POPULAR ASTRONOMY two or three loose copies of the chart of the Leonid Radiant which so many used with satisfaction last year. The fact that photography will be applied to the determination of the radiant at several Observatories need not discourage anyone from making the attempt to chart the meteor trails by hand, for, should the sky be cloudy at a few places which are adequately supplied with cameras, all photographic results might easily be lost.

We shall be pleased if observers, who are successful in charting a goodly number of the Leonids, will send copies of the charts to us. We cannot promise to publish more than a few of the best charts, but will endeavor to give a resumé of the results. If more copies of the chart are desired, they may be obtained by sending us the necessary postage.

Lectures on Celestial Mechanics.—A university course of lectures on Celestial Mechanics by Dr. G. W. Hill will be given in the astronomical lecture

room on Saturdays at 10:30 a. m. The course will begin on October 21st, 1899, and continue on every Saturday until finished, omitting Saturdays, December 2d, 23d and 30th. The course will be in continuation of that of the academic year 1894-5 and its character may be indicated by the following divisions:

I. Delaunay's Method of the Lunar Theory generalized and applied to Planets.
II. Glydèn's Method of Perturbations.
III. Gauss' Method with Secular Perturbations.
IV. General Expressions for the Secular Inequalities of the Solar System.
V. Poisson's Theorem on the Invariability of the Mean Distances.
VI. Periodic Solutions in the Planetary Problem.
VII. The Restricted Problem of Three Bodies.
VIII. General Considerations on the Stability of Motion of Planetary Systems.

Dr. Hill will give a somewhat full presentation of the subject rather than a rapid *résumé*. Short numerical illustrations will enable the hearer to comprehend the bearing of the principles enunciated on practical work. Conferences will be held with those desiring them. JOHN KROM REES.

Columbia University, New York.

Nice Observatory.—Although it is twelve years since the second volume of the Annals of the Observatory at Nice, France, was issued, and four volumes have succeeded it, the first volume (Tome I) has just been published. It contains complete descriptions of the Observatory and its equipment, a catalogue of the library and various tables constructed for the use of observers. It is accompanied by an Atlas containing carefully executed plans of the buildings and principal instruments. This Observatory is to be congratulated on having so wealthy and enthusiastic a patron as its founder, M. R. Bischoffsheim.

The Velocity of Meteors from Photographs.—Dr. W. L. Elkin, director of the Observatory at Yale University, writes as follows in "*The Astronomical Journal*" No. 469, p. 102:

We have been experimenting with an apparatus for determining the velocity of meteors photographically, on a principal similar to that devised by Lane as long ago as 1860, and to that used by Zenker in 1885 but without success apparently (see *Amer. Journal of Science*, Vol. XXX, p. 42, and *Astr. Nachr.*, Vol. CXIII, p. 228). The same plan has been recently suggested by Fitzgerald (*Astrophysical Journal*, Vol. IX, p. 50) and consists in rotating in front of the lens at a known rate a wheel carrying at intervals interceptors of the light falling on the lens. Our apparatus was placed on our meteorograph and was large enough to occult all of the six large lenses now in use. Our second station is now provided with six cameras and both instruments were brought into use during the favorable absence of the Moon in the first half of August. Unfortunately the nights of Aug. 10, 11 and 12 were completely overcast here, Aug. 9 partly so, so that no records of *Perseid* meteors seem to show on our plates. But on July 31, Aug. 7 and Aug. 8 each, a meteor trail from other radiants was secured at both stations, those of July 31 and Aug. 8 showing three or four interruptions and of Aug. 7 some ten or twelve on the Yale plates. It is of course a question as to whether the cosmical velocity can be deduced from these records, and it will be of considerable interest to see whether the results thus derived will agree with the known velocity of the *Leonids*, if we are fortunate enough to capture any trails next November. W. L. ELKIN.

YALE UNIVERSITY OBSERVATORY, 1899, Aug. 17.

The Paris Observatory.—The annual report of the Observatory of Paris for the year 1898, by the Director M. Loewy is accompanied by a beautiful phototype of a photograph of the Moon, taken Sept. 19, 1894, with the great equatorial *coudé*. Messrs. Loewy and Puiseux have devoted a large part of their time during the year 1898 to the production of a Lunar Atlas from photographs taken with the equatorial *coudé*. They find that but very few of the photographs taken will bear the necessary enlargement to the scale of the Atlas. Suspecting that the poor definition is due to currents of air within and in the vicinity of the instrument, the observers have made many experiments with a view to preventing these currents, without, however, any certain amelioration of the results.

During the months of June and July the same instrument, with the visual objective, was used by M. Hamy in order to measure the diameters of some of the satellites and asteroids by method depending upon the diffraction rings. He has a series of screens with openings of a considerable length and of widths differing in the several screens. The screens are placed successively in front of the objective and that one is noted which first causes the diffraction rings to vanish. Then the formula

$$l\varepsilon = 126.''1 + 96''.5 \left(\frac{a}{l}\right)^2 + \ldots\ldots$$

gives the diameter ε of the asteroid in seconds of arc, where a is the width in millimeters of the openings in the screen and l is the separation of their centers. M. Hamy finds for the diameters of the satellites of Jupiter the following values, referred to the mean distance of the planet from the Earth:

Satellite.....	I.	II.	III.	IV.
Diameter.....	0″.98	0″.87	1″.28	1″.31

The observations of the IVth satellite were very difficult and therefore the resulting diameter is uncertain.

The diameter of Vesta referred to the distance unity is found equal to 0″.54, in close agreement with Professor Barnard's measures.

The photographic work upon the chart of the sky, for the zone allotted to the Paris Observatory, is practically completed, it only remaining to replace a few defective plates. Sixty-two plates were obtained for the catalogue and forty-five for the chart during the year. The measures and reductions for the catalogue are being actively carried forward, 37,315 measures of 33,513 stars having been made in 1898.

Observations with the meridian circles and other routine work has been continued much as usual, one notable piece of work being the determination of latitude from 387 observations in 1897 and 1898 with the meridian circle *du Jardin*, giving as a result

48° 50′ 10″.40 in the direct position of the instrument.
48 50 10 .15 in the inverse " " " "

Corrected for flexure the resulting latitude of the instrument is 48° 50′ 10″.65.

Potsdam Astrophysical Observatory.—This Observatory having already published thirteen volumes of its researches, now begins a series devoted to the photographic chart of the sky. The first volume of this series contains an introduction by the Director, Dr. H. C. Vogel, describing the photographic refractor and the methods of measuring the plates and of reducing the measures. This

is followed by the results of the measures of 57 plates. These plates are numbered from 4 to 923, showing that only a comparatively small number of all the plates exposed have been measured. The measures given, however, comprise 20,627 rectangular coördinates of stars down to the 12th magnitude, all included within the zone from 31° to 38° of north declination. The rectangular coördinates for each star are accompanied by its approximate right ascension and declination for 1900.0 and its magnitude as estimated from the photograph and as given in the Bonn Durchmusterung, if found in the latter catalogue.

The Orbit of Sirius.—In *Astronomische Nachrichten*, No. 3588 Mr. H. J. Zwiers gives the results of a new determination of the orbit of the companion of Sirius, in which he had used the latest published observations, including those made at Lick Observatory during last winter. The following elements represent the observations remarkably well:

Perihelion	$T = 1894.0900$
Mean annual motion	$\mu = -7°.37069$
Period	$P = 48.8421$ years
Eccentricity	$e = 0.5875$
Inclination	$i = 46°\ 1'.9$
Longitude of ascending node	$\Omega = 44\ \ 30.2\ (1900.0)$
Angle of perihelion from node	$\pi - \Omega = 212\ \ 6.4$

Kiel Observatory.—Publication No. X of the Observatory at Kiel, Germany, issued in 1899, contains a thorough discussion of the method of determining time with a transit in the vertical circle of the pole star, by Paul Harzer, the Director of the Observatory. The writer also gives a working catalogue of stars for Kiel Observatory and several auxiliary tables which shorten the labor of reducing the observations.

Polaris.—The following statement from Professor Campbell of Lick Observatory has appeared in several newspapers recently. The authority seems to be good:

"The observations of Polaris," says The New York Times, "were made with the Mills spectroscope attached to the 36 inch telescope. From the well-known principle of the shifting of the line in the spectrum of a star, we can determine whether the star is approaching or receding from the observer and how rapidly. For most stars the velocity is constant. For some stars the velocity is variable, due to the attractions of companion stars.

"The recent observations of Polaris, at Lick Observatory, show that its velocity is variable. It is approaching the solar system now with a velocity of 8 kilometers per second. This will increase in two days to 14 kilometers, and in the next two days will decrease again to 8 kilometers. This cycle of change is repeated every four days. The bright Polaris, therefore, revolves about the center of gravity of itself and its invisible companion once in four days. The orbit is nearly circular and is comparable in size with the Moon's orbit around the Earth.

"Thi center of gravity, and therefore the binary system, is approaching the solar system at present with a velocity of 11½ kilometers per second. A few measures of the velocity of Polaris made here in 1896 gave its approach at the rate of 20 kilometers per second. Part of this change since 1896 could be due to a change in position of the orbit of the binary system, but most of it must have been produced by the attraction of a third body on the two bodies compris-

ing the four-day system. The period of revolution of the binary system around the center of gravity of itself and the third body is not known, but is probably many years.

Both companions of Polaris are invisible, but their presence is proved by disturbances which their attractions produce in the motion of the bright Polaris."

Athens Observatory.—The first volume of the Annals of the National Observatory of Athens was issued in 1898, by the Director Demétrius Éginitis. It is a large quarto volume of about 400 pages, devoted principally to an investigation of the climate of Athens.

The Sun Dial of Ahaz.—Your readers will be tired of this subject; I will only crave indulgence for a brief reply to Dr. Morrison's charge (p. 369) that I have misrepresented him. The words on which I relied form the concluding sentence of a note on p. 102, signed with his surname and initial. They are "It is simply a physical impossibility for the shadow to reverse its direction except within the torrid zone," and they immediately follow the statement that it makes no difference in what direction the edge which casts the shadow may be, or what the surface upon which it falls. Nothing could be more explicit. Should this really not have proceeded from Dr. Morrison's pen I owe him an apology, having been misled by the signature. His assertion on p. 368, that the equations "do not admit of the treatment" proposed "for the simple reason that h increases continually and φ is constant" is not explicit. If he refers to the differentiation with respect to h (see p. 206), it constitutes one of the most extraordinary statements I have ever seen; if to the evaluation of the limit of the indeterminate $\frac{d\theta}{dh}$, I fail to see any relevancy at all. In any case I am prepared to stand by what I have written.

S. A. SAUNDER.

Astronomical and Astrophysical Society of America.—The third annual meeting of the Astronomical and Astrophysical Conference was held at the Yerkes Observatory, Williams Bay, Wisconsin, Sept. 6-8, 1899. The first meeting convened in August, 1897, at the same place, the second was held at Harvard College Observatory in August, 1898.

At the conference for this year the following named persons were present: George C. Comstock, Director of Washburn Observatory, Madison, Wis.; S. J. Brown, Washington, D. C.; H. W. Dubois, Philadelphia; F. R. Moulton, University of Chicago, Chicago; A. W. Quimby, Philadelphia; E. W. Morley, Case Scientific School, Cleveland, Ohio; C. L. Doolittle, Director of Observatory, Philadelphia, Pa.; Wm. Harkness, Astronomical Director at the United States Naval Observatory, Washington, D. C.; Frank R. Whitman, Cleveland, Ohio; S. C. Reese, Princeton, N. J.; C. E. Rood, Beloit, Wis; A. St. C Dunston, Auburn, Ala.; M. E. Rice, Lawrence, Kansas; N. E. Dorsey, Baltimore, Md.; W. S. Adams, Chicago, Ill.; D. C. Miller, Cleveland, Ohio; G. W. Myers, University of Ill., Urbana, Ill.; Kurt Laves, University of Chicago, Chicago; D. A. Drew, Baraboo, Wis.; John N. Stockwell, Cleveland, Ohio; G. W. Hough, Director of Dearborn Observatory, Evanston, Ill; N. E. Bennett, Wilmington, Ohio; A. Hall, Jr., Director of the Detroit Observatory, Ann Arbor, Michigan; A. S. Flint, Madison, Wis.; J. C. Shedd, Madison, Wis.; Caroline E. Furness, Vassar College, Poughkeepsie, N. Y.; Ormond Stone, Director of the Leander McCormick Observatory, University of Virginia, Charlottesville, Va.; M. B. Snyder, Philadelphia; C. M.

Smith, Madison, Wis ; F. L. O. Wadsworth, Director of the Allegheny Observatory, Allegheny, Pa.; Wm. Gaertner, Instrument maker, Chicago, Ill.; O. L. Petitdidier, Instrument maker, Chicago, Ill.; Elizabeth Dobbin, Kansas City, Mo.; H. M. Goodwin, Boston, Mass ; John E. Davis, Madison, Wis.; Seb. Albricht, Milwaukee, Wis.; Henry Crew, Northwestern University, Evanston, Ill.; Robert R. Tatnall, Evanston, Ill.; A. B. Porter, Evanston, Ill.; George E. Hale, Director of the Yerkes Observatory, Williams Bay, Wis.; E. B. Frost, T. Ellerman, G. W. Ritchey and E. E. Barnard, members of the staff at the Yerkes Observatory.

The following is a list of the papers presented at this meeting of the society:

Transit micrometer of the Washburn Observatory and slot-screen apparatus, A. S. Flint.

The position of the axis of Neptune from perturbations of its satellite, S. J. Brown.

Notes on the Annular nebula in Lyra; The fifth satellite of Jupiter, Triangulation of star clusters, and measures of the difference of diameters of the stars Atlas and Pleione, E. E. Barnard.

Problems of modern celestial mechanics treated by the use of power series, F. R. Moulton.

On the semi diameters of the Sun and the Moon, Wm. Harkness.

On the motion of Hyperion, Ormond Stone.

The Review of Harvard Photometry, E. C. Pickering.

Determination of the principal term of nutation from observations of Eros, Kurt Laves.

Wave-length of the green coronal line, W. W. Campbell.

Aberration Constant from meridian zenith distances of Polaris, Asaph Hall, Jr.

The Ring Nebula in Lyra, J. E. Keeler.

Notes on carbon in the chromosphere, the connection between stellar spectra of the third and fourth types and some new forms of spectroheliographs, G. E. Hale.

Notes on the radiation of stellar spectra, Titanium as a comparison spectrum, and corrections of absolute wave-lengths due to the Earth's motion, E. B. Frost.

Suggestions for the determination of stellar parallax by means of photography, Frank Schlesinger.

Note on the relations between the visual and photographic light curves of variable stars of short period, S. I. Bailey.

The periods of the variable stars in the cluster Messier 5, S. I. Bailey.

The spectroscopic binaries, Capella and Polaris, W. W. Campbell.

Refraction of Red Stars, F. L. Chase.

Some researches in Stellar Color, George C. Comstock.

Laplace's Ring Nebula Hypothesis, F. R. Moulton.

Lunar potential forces applied to celestial mechanics, Kurt Laves.

On the actinism or photographic power of the Moon in a total eclipse, G. W. Hough.

The phonochronograph and its advantages in certain astronomical observations, M. B. Snyder.

The officers of this new astronomical society elected at this meeting were as follows:

President—Simon Newcomb.

First Vice President—C. A. Young.

Second Vice President—George E. Hale.

Secretary—George C. Comstock.

Treasurer—C. L. Doolittle.

Councilors for two years—E. C. Pickering, J. E. Keeler.

Councilors for one year—E. M. Morley, Ormond Stone.

Professor Frost will act as secretary until Professor Comstock is able to assume the duties of the office.

The committee on the total solar eclipse of May 28, 1900, consists of Professor Simon Newcomb, Chairman; Professor Hale, Secretary. Professor Barnard and Professor Campbell presented a preliminary report.

On the evening of the 6th, an informal reception was tendered the members of the Conference by Professor and Mrs. Hale.

The afternoon of the 7th an excursion was made on Lake Geneva. Mr. Martin Ryerson and Mr. E. Ayer very kindly supplied their handsome steamers for the excursion and everyone enjoyed the trip around the beautiful lake.

The nights of the 6th and 7th, the great telescope was opened, and the astronomers assembled observed some of the nebulae and clusters through it, though the clouds made it difficult to see much.

It has been for some time in the minds of at least a few astronomers that a more permanent organization for the benefit of science should be formed than that which has, for the last two years, consisted of informal conferences. Action of this kind was taken at this meeting and a society was organized, to be known as the Astronomical and Astrophysical Society of America and Professor Simon Newcomb, of Washington, D. C., was chosen as its first president.

It is a matter of little surprise to us that the name, "American," is so much in favor in designating new societies and new magazines and some other new things belonging to the United States. If our country owned even one-half of the territory known as North America, there would seem to be more reason for so large a name. It is not probable that our Canadian friends, or those of Mexico, Central America or South America will at all complain at the choice of the name of this new society although less than two score scientific gentlemen, largely from the eastern states, have selected it. It is no matter of concern to us what name the society bears, what it shall be able to do is vastly more important. All that is referred to now is whether or not the society has chosen the most fitting title if the purpose is to give it national significance.

We hope to have later a good analysis of the papers which were presented and discussed in this meeting of the society.

Numbering of the New Asteroids.—In *Astronomische Nachrichten*, No. 3570, Dr. Bauschinger gives the final numbering of such of the recently discovered asteroids as have been observed a sufficient number of times to determine their orbits.

Number.	Provisional Designation.	Discovered By	Date.
(437)	1898 DP	Charlois	1898 July 16
(438)	1898 DU	"	" Nov. 8
(439)	1898 EB	Coddington	" Oct. 13
(440)	1898 EC	"	" Oct. 13
(441)	1898 ED	Charlois	" Dec. 8
(442)	1899 EE	Wolf-Schwassmann	1899 Feb. 15
(443)	1899 EF	Wolf-Schwassmann	" Feb. 17
(444)	1899 EL	Coggia	" Mar. 31

No. (439) 1899 EB has received the name Ohio. Eleven other asteroids discovered within the past year have either been identified with those already known or have failed to receive the requisite number of observations.

The Life of a Star is the subject-matter of a letter from Professor Perry to Sir Norman Lockyear and published in *Nature*, July 13, 1899. From the introductory part of this letter it appears that Mr. Lockyer had asked Professor Perry to give his views on the value of such speculations as have been made by mathematical physicists on this theme. Professor Perry communicates a letter of considerable length, in which he notices Dr. T. J. J. See's article published in *The Astronomical Journal*, Feb. 6, 1899 and in this journal in March following, under the title of The Fundamental Law of Temperature for Gaseous Celestial Bodies. He says, "we have all sorts of temperatures in a star, but whether Dr. See takes average temperature, or the temperature of some layer at a definite depth below the surface he is certainly wrong." He says "Dr. See is also wrong in assuming gravitational pressure at the surface of a star, whereas, in physics we do not admit that there can be such a pressure in the absence of outside matter."

In Ritter's articles, abstracts from which have been published in the *Astrophysical Journal*, Dec. 1898, he claims that the author assumes "that the radiating layer on the outside of the star is of constant mass," and that the rate of radiation is proportional to the fourth power of the average temperature of the layer. These assumptions Professor Perry thinks must be regarded quite arbitrary.

He also speaks of the work of Homer Lane published, in a classical paper, in *Silliman's Journal* in 1870, Vol. I, page 57, in which he "makes the assumption that Dulong and Petit's law of radiation is true for solar radiation, and he uses it to calculate the temperature of the radiating layer, which he finds to be 28,000° F." If this law is obeyed at laboratory temperatures, Professor Perry thinks it would not necessarily express the radiation of enormous temperatures of hot layers of gas having other layers above and below of varying temperatures. This matter was well presented by Professor Young, in the May number of this publication on pp. 225 and 226, under the title of Lane's law of increase of temperature in a gaseous sphere contracting from the loss of heat.

Professor Perry further speaks of gaseous stars and considers a perfect gas in a state of convective equilibrium, in the free use of mathematical calculation which is intended for the ready eye of the physicist. The results are interesting when applied to stars in general and will best be understood by those who read the paper in full.

A Brilliant Fireball.—On the night of Aug. 7, 1899, while observing comet Tempel 1899 *c*, I was startled by a vivid illumination of the floor, as if by a flash of lightning. Not caring to lose my comet observation I did not look at my watch instantly, but in a few seconds I did so, and the best estimate of the time which I can make is $13^h\ 17^m\ 45^s$. Glancing up through the dome-slit I saw a portion of the meteoric trail, which was very bright and narrow and of the color of Sirius. It faded rapidly from the western end, which I saw, eastward, and was lost in a very few seconds, beyond the eastern edge of the dome-slit. That portion of the meteoric trail which I saw was horizontal and pointed directly at β Aquarii. Five minutes after this apparition I unexpectedly heard a rumbling which sounded as if a couple of distant cannon had been fired in quick succession (one or two seconds apart).

Mr. R. P. Raynolds of 1352 Lincoln Ave., Denver, wrote me as follows with reference to this meteorite:

"I was on Thirteenth Ave., near Pearl, on the morning in question, at about

1:15, and was suddenly startled by a bright flash of light. I looked up and saw a large streak of fire shooting across the sky. It resembled a huge sky-rocket and traveled from east to west, slightly inclined to southwest. It was not directly over me, but nearly so, being a little to the south. I thought I heard it hiss as it went by, but this may have been my imagination. The trail left by it lasted for several minutes after the flash."

Mr. John Nicholls, Jr., of Golden, Colo., sent me the following information:

"About 1:20 o'clock Mr. J. D. Williams of this place, and myself were chatting on the street when suddenly the whole place became light as day, and we heard a loud, rushing noise; looking up we beheld what seemed to be a big ball of fire rush through the heavens from the east to the west and bursting way in the west. In its first onward rush through the sky it seemed to separate, and leave behind it a kind of a tail of fire. When the ball of fire rushed though the sky, it left behind it a faint greenish tinge. HERBERT A. HOWE.

University Park, Colo.

A Remarkable Aurora.—A curious phase of Aurora Borealis was visible in this portion of the country Wednesday evening, June 28, '99. As twilight began to fade into darkness we noticed the bright lines due to "Northern lights" shooting across the northern heavens. Between 8:30 and 9 p. m. a bright jet about 1 or 2 degrees wide, shot up almost due east of us. Possibly 10 degrees above the horizon it widened out to 5 or 7 degrees, and this broad band of light swept across the sky just south of our zenith, then it curved slightly towards the north, reaching the western horizon at almost the exact place where the sun had set. The ordinary Aurora jets seemed pale in comparison with this bright band. The band had the appearance of an illuminated cloud sweeping rapidly across the sky yet ever remaining the same in appearance. The waves of this band seemed to be moving westward as rapidly as clouds move when driven by an unusually high wind. The band was so bright that second magnitude stars behind it were entirely occulted. This condition of affairs lasted for at least two hours.

A. M. MCDERMOTT.

Rescue, Mich.

The Tydeman Astronomical Lectures.—We notice with pleasure an account of a course of lectures given by Rev. E. M. Tydeman in a recent number of the *Camden Echo*. Mr. Tydeman is a well-known maker of astronomical instruments. The following is an extract from the notice referred to:

Rev. Edmund M. Tydeman commenced a series of lectures last Saturday evening in Fyne Poynt Park. His theme was "Astronomy," the oldest of the sciences. We know of no one better qualified in this city to speak on this subject, and we listened with a great deal of pleasure and we hope considerable profit to the first lecture, or rather address, on this interesting subject. He will give another of these talks on astronomy to-night at 8 o'clock in the same place, and we recommend all people who desire to know more about the stars and planets to go and listen to him. The address was not dull and dry but full of interest. Aug. 19, 1899.

Milne's Plane and Solid Geometry is a new book of 384 pages, by a well known author, now President of the New York State Normal School at Albany, N. Y.

The main features of this new work which deserve special mention are its

"inventional" methods, the questions, the exercises, the summaries and the abundance of theorems for demonstration.

The book itself is a sample of elegance that a true teacher will admire. The American Book Company, the publishers, know how to make a neat and a finished text-book, and they should have full credit for such merit.

While the matter of the text is not new the methods adopted by the author and made ready to the hand of the teacher seem to us to be excellent. The questions to be answered and the figures to be drawn at the time of assigning a lesson, and before its preparation, is a most important step in bringing a beginner face to face with a task in so difficult a branch of study as the elements of Geometry. Then, the statement of definitions, concepts and themes to be proved and instructions concerning them are accurate, ample and direct for the purpose intended. The attention of teachers in this branch is called to the neat logic of proofs for theorems after the student has made something of a start in the study. The aim of the author to exercise the reasoning powers of the student in the most promising way is very apparent. The consequence of this is that the student can not memorize, but that he will be interested in his study, and very generally come to like it so much as to forget that he has a required task to perform, while he is pleasantly mastering new things delightful to know.

It seems to us that this new book must find favor in the hands of teachers very generally when they know of its real merits.

The Indian Eclipse of 1898.—We have been favored with a copy of the report of the expedition organized by the British Astronomical Association to observe the total solar eclipse of 1898, Jan. 22. The report was prepared by the Secretaries of the Association, E. Walter Maunder and John Bacon, the same being edited by Mr. Maunder.

The publication consists of 172 pages with 52 beautiful illustrations to accompany the text, and the printing is done on a fine quality of plate paper, making as a whole a piece of admirable work. We give below an extract from Mr. Maunder's personal report:

"The spectrum of the corona was in the main a bright continuous spectrum of irregular brilliancy. The C, D_3, F, and *G* lines were seen as brilliant sharply defined semicircles, and several very much shorter arcs were seen for a little time, the *b* triplet being one. But failing to detect "1474 K," I turned my attention after a time to the corona itself.

When I turned back to the spectrum, the coronal line was clearly seen, though very faint. Mid-totality was then past, and the line was only seen on the west side of the Moon. It was traced through something less than half a circumference and more than one-third—say 140°.

It was much fainter than the arcs of the C, D_3, F, and *G* lines, but was broader, perhaps twice as broad. It was also diffused on its outer edge, not sharp as the other four lines were. But I could trace in it neither rifts nor rays. I estimated its breadth (at the cry of "twenty") as between 1/5 and 1/6 of the Moon's diameter, or about 6′ of arc.

The eclipse now drew rapidly to its close; at the cry of "ten" the C, D_3, F, and *G* lines were evidently brightening, and other shorter arcs were appearing. In the next four seconds the bright lines multiplied exceedingly, a number of bright threads of continuous spectrum flashed out and ran together, a flood of sunshine broke out and the eclipse was over.

The time-keeper, Mr. Ramrao Subarao, clerk to Mr. Morris, called out "Close cameras" at the fifth beat after the ten seconds, but the eclipse was then over by a full second. As the clock had been arranged for 118 seconds, the eclipse had lasted 112 seconds, or 4 seconds less than had been expected.

It has long been known that the coronal spectrum is from three distinct sources. One, a purely continuous spectrum, probably from glowing particles of cosmical dust; a second, with difficulty distinguished from it, of reflected sun-

light, *i. e.* a continuous spectrum interrupted by the dark Fraünhofer lines; and the third a bright-line spectrum due to glowing gases. It would seem, from the comparison of the observations of different eclipses, that the third kind of spectrum varies in its brightness, relatively to the sum of the other two, very much from time to time. The coronal spectrum in 1893 and 1882 and 1883—*i. e.*, years of maximum—seems to have given readier evidence of bright lines than in years nearer minimum. The present occasion was therefore not a good one for such an observation as I had undertaken; and if repeated in 1900, a much higher dispersion should be employed in order to get rid as far as possible of the light from the first two sources.

So far as my observation at this eclipse goes, it points to the gas, which we may call "coronium" for distinctness, being distributed pretty evenly round the Sun to a distance of about 160,000 miles, and that it is not specially associated with the striking irregularities of the visual corona. It must be however remembered that the corona as seen is far brighter up to about this limit than above it; that the "inner corona," in short, corresponds pretty closely to this distribution of "coronium."

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